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## Seasonal dynamics of soil nematode community in an oak-hornbeam wood

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**Abstract.** Soil nematode community was studied in a deciduous forest in the Natural Protected Area Chuchelský háj in Prague. The characteristic of the community was studied as follows: species composition, diversity, abundance, trophic structure and seasonal dynamics. The community was characterized by a high number of species (98) but a relatively low mean abundance ( $3.94 \times 10^3 \text{ ind.m}^{-2}$ ). The most abundant genera were *Plectus*, *Filenchus*, *Rhabditis* and *Eudorylaimus*.

Oak forests or mixed oak forests cover a significant area on the territory of the Czech Republic. Free-living nematodes are an important part of soil fauna in those ecosystems composing diverse and abundant communities. Those communities on the European territory were studied by Šály (1973) in Slovakia, Bassus (1962) in Germany, Wasilewska (1970, 1971) in Poland or Solovyeva (1986) in the European part of the former Soviet Union. In the Czech Republic, nematodes of an oak forest in South Bohemia were studied by Háněl (1994).

The aim of the present study was to investigate the nematode community of an oak-hornbeam forest near Prague in Central Bohemia, a part of the Natural Protected Area Chuchelský háj.

### MATERIAL AND METHODS

Investigations were carried out in an oak-hornbeam forest (*Melampyro nemorosi-Carpinetum*) in the Chuchelský háj near Prague in Central Bohemia, north-west slope, 275 m a.s.l., square code 5952 in the network of squares on the map of the Czech Republic for faunistic research. This locality is a part of the Natural Protected Area.

The soil is mesotrophic brown on silurian rock composed of diabases, limestones and slates. The characteristic of the soil is in Tab. 1.

The climate of the region is characterized by a warm and dry summer, a short winter with a very short duration of snow cover (Quit 1971). Mean annual temperature and sum of precipitation in 1990 were 10.7°C and 409 mm, respectively, corresponding values in 1991 were 9.3°C and 409 mm. The seasonal changes of temperature and precipitation are given in Tab. 2.

Soil samples (7 x 7 cm) were taken monthly from September 1990 to August 1991 in 7 replicates down to the depth of 10 cm. Nematodes were isolated from 5g of mixed soil using the modified Baermann funnel method for 24 hours, fixed in FAA and transferred to glycerin (Šály 1983).

The study material consisted of 5,252 nematodes. Individuals were determined to species, specimens in nematode genera were counted. Shannon index of diversity was calculated from genera abundance according to the formula:

\* corresponding author

$$H' = - \sum_{i=1}^n [N_i/N] \cdot \ln [N_i/N]$$

$N_i$  - abundance of  $i$ -th genus

$N$  - total abundance

$n$  - number of genera (Odum 1977)

Table 1 Soil characteristics of locality

	1989	1990
humus (%)	12.10	8.40
C (%)	7.01	4.88
N (%)	0.76	0.27
C/N	9.22	18.07
CaO (mg/100g soil)	988.00	151.00
MgO (mg/100g soil)	19.70	12.90
P <sub>2</sub> O <sub>5</sub> (mg/100g soil)	8.90	9.00
K <sub>2</sub> O (mg/100g soil)	17.30	9.30
pH (H <sub>2</sub> O)	5.33	4.88
pH (KCl)	4.64	3.94

Table 2 Mean monthly temperatures (°C) and sum of precipitation (mm) from September 1990 to August 1991

	1990				1991							
	IX	X	XI	XII	I	II	III	IV	V	VI	VII	VIII
mm	49	31	63	19	8	11	28	24	37	90	46	56
°C	12.9	10.5	5.2	0.9	2.0	2.3	6.9	8.5	10.9	16.3	20.8	19.3

The species were divided into five trophic groups: bacterivores, fungivores + facultative plant feeders, plant feeders, omnivores, carnivores (predators). See check list Tab 3. Pearson's correlation coefficients were calculated between temperature - abundance, and precipitation - abundance.

Seasonal changes of the nematode community were evaluated using agglomerative classification of samples, genera abundance transformed by  $\log(x+1)$ , Euclidean distance, Ward's method (Wishart 1981). Nematode material is deposited with the authors.

## RESULTS

A total of 98 species, 64 genera, 32 families and 9 orders of soil nematodes were found in the study plot (Tab 3). Dominant genera were as follows: *Filenchus* ( $1.34 \times 10^5$  ind.m<sup>-2</sup>, 34.07%), *Plectus* ( $0.40 \times 10^5$  ind.m<sup>-2</sup>, 10.05%), *Eudorylaimus* ( $0.32 \times 10^5$  ind.m<sup>-2</sup>, 8.15%), and *Rhabditis* ( $0.22 \times 10^5$  ind.m<sup>-2</sup>, 5.52%). The population maximum of the genus *Filenchus* was found in October 1990, those of the genus *Plectus* in February 1991, the genus *Eudorylaimus* in December 1990, the genus *Rhabditis* in January 1991. Mean annual value of the Shannon index of diversity was 2.73, monthly values fluctuated from 1.54 to 2.85.

The mean abundance of nematodes was  $3.94 \times 10^5$  ind.m<sup>-2</sup>, its seasonal changes are given in Fig 1. The highest abundance was found in January 1991. Among the trophic groups fungivores



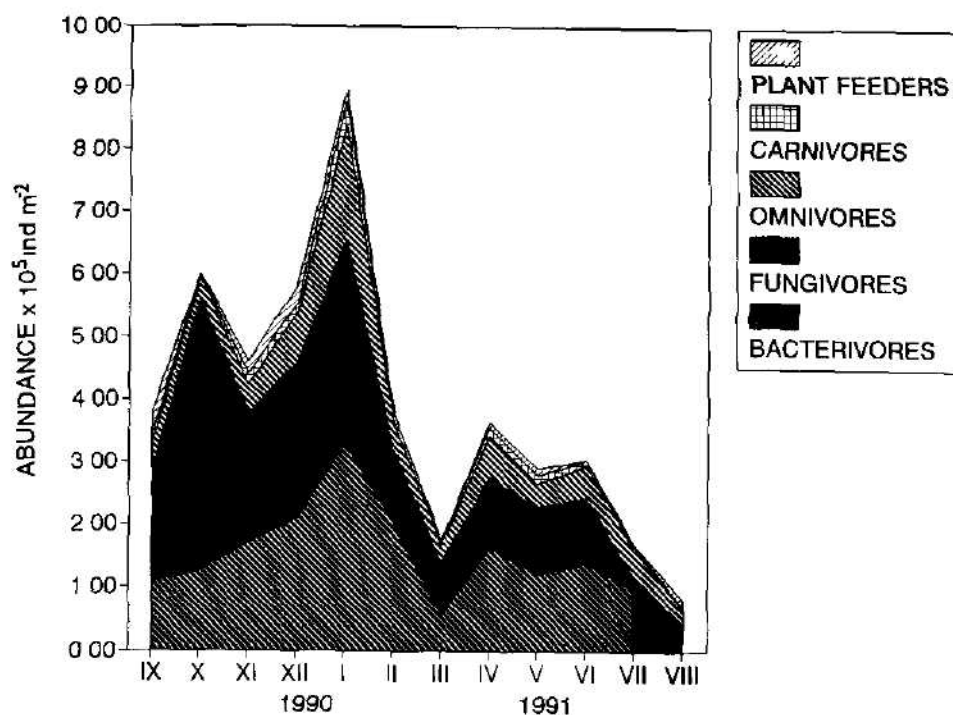


Fig. 1 Seasonal changes of nematode trophic groups

facultative plant feeders were the most abundant nematodes and their seasonal changes were very similar to those of the total nematode community. Microbivores had their peak of abundance in January 1991 as well as omniphages and predators (Fig. 1).

The development of nematode community at different sampling months is shown in Fig. 2. The community structure in January 1991 was different from that in the other months, mainly due to the high abundance of the genera *Filenchus*, *Rhabditis*, *Acrobeloides* (Cobb, 1924), *Aporcelaimellus* Heyns, 1965 and *Tylencholaimus*. Samples from 1990 were clustered into the group A. There was a high similarity between samples taken in April, May, June and these samples were more similar to the community in February (group B) than to that in March, July and August (group C).

#### DISCUSSION

The oak-hornbeam forest studied was characterized by a high number of nematodes species as well as the oak-dominated forests studied by Bassus (1962), Šály (1973), Solovyeva (1986) and Háněl (1994). The highest values of the Shannon index of diversity were found in August 1991 (2.85), November 1990 (2.82) and in January 1991 (2.80). Similarly, Háněl (1994) found the highest values of the Shannon index in August in an oak forest in South Bohemia. It is interesting, that the lowest abundance of nematodes in the studied forest was in August, whereas on the contrary Háněl (1994) found the peak of abundance in that month.

The abundance of nematodes in oak forests is very variable. Volz (1951) found the maximum abundance of  $29.9 \times 10^6 \text{ ind.m}^{-2}$  in an oak-ash forest in Germany, Háněl (1994) found the

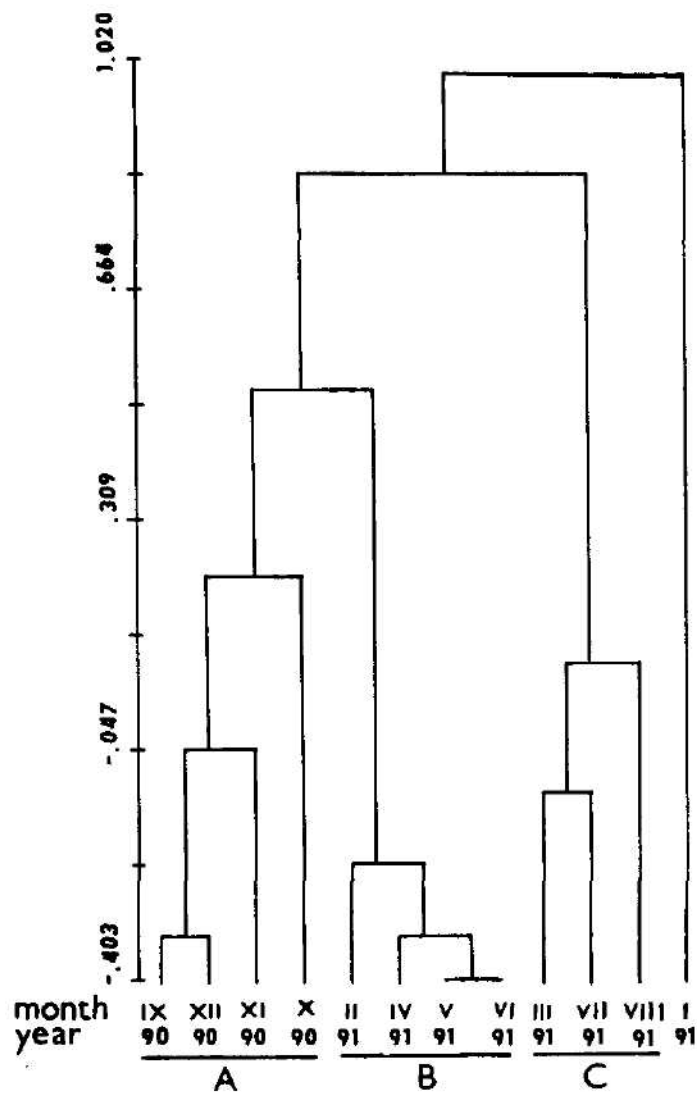


Fig. 2. Cluster analysis of nematode genera ( $\log(x+1)$  of abundance, Euclidean distance).

minimum value of  $0.35 \times 10^6 \text{ ind.m}^{-2}$ . The average abundance of nematodes in deciduous forests varies in range of several millions of individuals per  $\text{m}^2$  (Sohlenius 1980, Wasilewska 1981). In comparison with these data, the abundance of nematodes in the study plot was low. The cause of this phenomenon could consist in dry weather in the year investigated as indicated by negative correlation of nematode abundance either with average month temperatures ( $r = -0.587$ ,  $n = 12$ ,  $P = 0.05$ ), or with precipitation ( $r = -0.424$ ,  $n = 12$ ), too. Dry summer was probably responsible for the absence of the peak of abundance in August found by Hájek (1994) in an oak forest in South Bohemia, however, the high Shannon index value of the nematode community remained unaffected by shortage of soil water.

Microbivorous nematodes usually dominate in oak forests. Arpin and Ponge (1986) found almost equal proportion of bacteriophagous and mycophagous nematodes in an oak forest in France as well as in the oak-hornbeam forest studied. The genera *Filenchus*, *Eudorylaimus*, *Plectus* and *Rhabditis* dominated in the forest studied and the same dominants were also ascertained in the oak forest studied by Háněl (1994). In the oak-hornbeam forest in Slovakia *Rhabditis* was the dominant bacteriophagous genus, *Aphelenchus* Bastian, 1865 was dominant in the mycophages (Šály 1973). True phytophagous nematodes had a low abundance in the forests studied and in the forest studied by Háněl (1994), Šály (1973) found a high abundance of the phytophagous species *Helicotylenchus multicinctus* (Cobb, 1893). These differences are probably related to a different soil profile and herbaceous undergrowth in the forests compared.

#### SUMMARY

1. A total of 98 species of the soil nematodes were found in the oak-hornbeam forest.
2. The average nematode abundance was  $3.94 \times 10^5 \text{ ind.m}^{-2}$ . The maximum abundance value was found in January 1991 ( $9.03 \times 10^5 \text{ ind.m}^{-2}$ ), the minimum value was in August 1991 ( $0.83 \times 10^5 \text{ ind.m}^{-2}$ ). The dominant genera were *Filenchus*, *Eudorylaimus*, *Plectus* and *Rhabditis*.
3. Microbivorous nematodes represented the greater part of the nematode community, the abundance of parasites on higher plants was low.

Table 3. Check-list of nematode species in oak-hornbeam forest, B - bacterivores, F - fungivores, P - plant feeders, O - omnivores, C - carnivores

##### order: MONHYSTERIDA

1. *Monhystera* Bastian, 1865 sp. (B)
2. *Eumonhystera vulgaris* (de Man, 1880) (B)
3. *Geomonhystera villosa* Bütschli, 1873 (B)

##### order: ARAEOLAIMIDA

4. *Anaplectus granulosus* (Bastian, 1865) (B)
5. *Plectus acuminatus* Bastian, 1865 (B)
6. *Plectus longicaudatus* Bütschli, 1873 (B)
7. *Plectus parvus* Bastian, 1865 (B)
8. *Plectus rhizophilus* de Man, 1880 (B)
9. *Plectus* Bastian, 1865 sp. (B)
10. *Ceratoplectus armatus* Bütschli, 1873 (B)
11. *Tylocephalus auriculatum* (Bütschli, 1873) (B)
12. *Wilsonama otophorum* (de Man, 1880) (B)
13. *Cylindrolaimus* de Man, 1880 sp. (B)

##### order: CHROMADORIDA

14. *Chromadorina* Filipjev, 1918 sp. (B)

##### order: RHABDITIDA

15. *Metateratocephalus crassidens* de Man, 1880 (B)
16. *Teratocephalus terrestris* (Bütschli, 1873) (B)
17. *Teratocephalobus paratenus* Eroshenko, 1973 (B)
18. *Acrobeloides nanus* (de Man, 1880) (B)
19. *Cephalobus persegnis* Bastian, 1865 (B)
20. *Cephalobus troglolithus* Andrassy, 1967 (B)
21. *Heterocephalobus elongatus* (de Man, 1880) (B)
22. *Eucephalobus oxyuroides* (de Man, 1876) (B)

- 23 *Eucephalobus striatus* Bastian, 1865 (B)
- 24 *Acrobeles* Linstow, 1877 sp (B)
- 25 *Cervidellus hamatus* Thorne, 1937 (B)
- 26 *Panagiolaimus rigidus* (Schneider, 1866) (B)
- 27 *Bursilia monhystera* (Butschli, 1873) (B)
- 28 *Rhabditis* Dujardin, 1845 sp (B)
- 29 dauer larvae (B)

order APHELENCHIDA

- 30 *Aphelenchus avenae* Bastian, 1865 (F)
- 31 *Paraphelenchus pseudoparietinus* (Micoletzky, 1992) (F)
- 32 *Aphelenchoides saprophilus* Franklin, 1957 (F)
- 33 *Aphelenchoides parietinus* (Bastian, 1865) (F)
- 34 *Aphelenchoides* Fischer, 1894 sp 1 (F)
- 35 *Aphelenchoides* Fischer, 1894 sp 2 (F)
- 36 *Aphelenchoides* Fischer, 1894 sp 3 (F)
- 37 *Semura* Fuchs, 1931 sp (C)

order TYLENCHIDA

- 38 *Filenchus vulgaris* (Brzeski, 1963) (F/P)
- 39 *Filenchus filiformis* (Butschli, 1873) (F/P)
- 40 *Filenchus discrepans* (Andrássy, 1954) (F/P)
- 41 *Filenchus helenae* (Szczypiel, 1969) (F/P)
- 42 *Filenchus minutus* (Cobb, 1893) (F/P)
- 43 *Filenchus* (Andrássy, 1954) sp 1 (F/P)
- 44 *Filenchus* (Andrássy, 1954) sp 2 (F/P)
- 45 *Lelenchus leptosoma* (de Man, 1880) (F/P)
- 46 *Tylenchus davamei* Bastian, 1865 (F/P)
- 47 *Tylenchus* Bastian, 1865 sp (F/P)
- 48 *Paratylenchus* Micoletzky, 1922 sp (P)
- 49 *Gnathacus* Raski, 1962 sp (P)
- 50 *Matenchus bryophilus* (Steiner, 1914) (F/P)
- 51 *Matenchus* Andrassy, 1968 sp (F/P)
- 52 *Ditylenchus* Filipjev, 1936 sp (F)
- 53 *Costenchus costatus* (de Man, 1921) (P)
- 54 *Boleodorus volutus* Luna et Siddiqui, 1963 (F/P)
- 55 *Fylenchorhynchus* Cobb, 1913 sp (P)
- 56 *Helicotylenchus* Steiner, 1945 sp (P)
- 57 *Rotylenchus* Filipjev, 1936 sp (P)

order ENOPIIDA

- 58 *Alaimus primitivus* de Man, 1880 (B)
- 59 *Alaimus meyeri* Andrassy, 1961 (B)
- 60 *Alaimus* de Man, 1880 sp (B)
- 61 *Ampludelus dolichurus* (de Man, 1876) (B)
- 62 *Prismatolaimus dolichurus* de Man, 1880 (B)
- 63 *Prismatolaimus intermedius* (Butschli, 1873) (B)
- 64 *Bastiania gracilis* de Man, 1876 (B)
- 65 *Tripyla filicaudata* de Man, 1880 (C)
- 66 *Tripyla gigantea* Daday 1897 (C)
- 67 *Tripyla* Bastian, 1865 sp 1 (C)
- 68 *Tripyla* Bastian, 1865 sp 2 (C)
- 69 *Tobrilus* Andrassy, 1959 sp (C)

70. *Ironus* Bastian, 1865 sp. (C)

order: MONONCHIDA

71. *Clarkus papillatus* (Bastian, 1865) (C)

72. *Coomansus parvus* (de Man, 1880) (C)

73. *Mononchus* Bastian, 1865 sp. (C)

74. *Iotonchus sinmenensis* (Kreis, 1924) (C)

75. *Iotonchus* (Cobb, 1916) sp. (C)

76. *Mylonchulus brachyuris* (Bütschli, 1873) (C)

77. *Mylonchulus* (Cobb, 1916) sp. (C)

78. *Anatonchus tridentatus* (de Man, 1876) (C)

order: DORYLAIMIDA

79. *Dorylaimus* Dujardin, 1845 sp. (O)

80. *Mesodorylaimus* Andrassy, 1959 sp. (O)

81. *Eudorylaimus carteri* (Bastian, 1865) (O)

82. *Eudorylaimus parvus* (de Man, 1880) (O)

83. *Eudorylaimus* Andrassy, 1959 sp.1 (O)

84. *Eudorylaimus* Andrassy, 1959 sp.2 (O)

85. *Eudorylaimus* Andrassy, 1959 sp.3 (O)

86. *Aporcelaimellus obscurus* (Thorne et Swanger, 1936) (O)

87. *Aporcelaimellus obtusicaudatus* (Bastian, 1865) (O)

88. *Tylencholaimus stecki* Steiner, 1914 (O)

89. *Tylencholaimus mirabilis* (Bütschli, 1873) (O)

90. *Tylencholaimus* de Man, 1876 sp. (O)

91. *Tylencholaimellus* Cobb in Cobb, 1915 sp. (O)

92. *Diphtherophora communis* de Man, 1880 (O)

93. *Longidorella* Thorne, 1939 sp. (O)

94. *Longidorus elongatus* (de Man, 1876) (O)

95. *Nygolaimus brachyuris* (de Man, 1880) (O)

96. *Paraxonchium laetificans* (Andrassy, 1956) (O)

97. *Pungentus* Thorne et Swanger, 1936 sp. (O)

98. *Enchodelus* Thorne, 1939 sp. (O)

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**Cochlear hair cell population in two primate species  
(*Cercopithecus aethiops* and *Macaca arctoides*)**

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**Cochlea, hearing, inner hair cells, primates**

**Abstract.** Basic morphological and morphometrical aspects of the cochlea in two primate species have been studied. Six adult individuals of the Vervet Monkey (*Cercopithecus aethiops*) and four individuals of the Stumptail Macaque (*Macaca arctoides*) have been involved. Standard paraffin sectioning and surface specimen techniques were used for the assessment. General cochlear morphology is very similar in the two species under study. Numbers and densities of cochlear hair cells are slightly higher in the Macaque than in the Vervet. While the distribution of outer hair cells is also similar in the two species, the inner hair cell distribution differs. However, neither in the Vervet, nor in the Macaque the hair cell distribution correlate with the audiogram. Vague correlation between the audiogram and the inner hair cell distribution found in the Vervet cochlea cannot be considered as strong evidence. Hence, the quantitative aspect of the hair cell distribution in the two primate species studied resembles more the situation in man than in nonprimate mammals where such correlation has been repeatedly found.

**INTRODUCTION**

Several mammalian species from different taxonomic groups were studied as to the basilar membrane length, width or thickness, number of cochlear hair cells, changes in hair cell density distribution along the spiral organ of the inner ear, etc.

It has been already found that in majority of species studied so far there are conspicuous variations in the densities of hair cells in the cochlea. These variations followed a similar (or even identical) pattern in all individuals of a given species (Ehret & Frankenreiter 1977, Burda & Voldřich 1980, Burda & Úlehlová 1983, Burda 1984, Burda & Voldřich 1984, Burda et al. 1988a, Burda et al. 1988b, Burda et al. 1989 etc.).

Burda & Voldřich (1984) proposed that the above mentioned species-specific variations may be of a great importance for frequency resolution and/or intensity discrimination capabilities, because in number of mammals studied there is a perfect correlation between the functional curve of auditory thresholds (audiogram) and the morphometrical curve of hair cell density distribution (Ehret & Frankenreiter 1977, Burda & Voldřich 1980, Burda & Úlehlová 1983, Burda 1984 etc.).

Controversially, in man, changes of hair cell density distribution along the basilar membrane are small, interindividual variations in hair cell counts are high and do not correlate with the audiometrical curve (Úlehlová & Voldřich 1987).



This controversy provokes several questions about the applicability of various mammalian models for the study of human auditory function. It seems to be a logical consequence that for the purpose of human studies other primate species would be the optimal models. However, apart from man, no other primate species has been studied in detail from this aspect. Even the review article on the comparative cochlear morphology published recently by Nadol (1988) does not contain the basic morphological data on basilar membrane length and width, hair cell numbers and densities etc.

The purpose of this contribution is to fill this gap and bring some new data on the mammalian cochlear morphology and morphometry. In addition, the authors wish to ascertain whether the cochlear hair cell populations of two different species of old world monkeys show any species-specific variations which might be correlated with the audiometrical curve (similarly as in mammals from lower taxonomic groups) or whether the hair cell population resembles the seemingly "unremarkable" quantitative pattern of the human organ of Corti.

#### MATERIAL AND METHODS

Twelve cochleae of six adult individuals of the Vervet Monkey (*Cercopithecus aethiops*) and eight cochleae of four adult individuals of the Stumptail Macaque (*Macaca arctoides*) are involved in this study. All subjects were nontreated control animals from the colony of the Institute of Sera and Vaccines (Prague, Czech Republic).

After sodium pentobarbital euthanasia, the middle ear cavity was exposed by a transtympanic approach and the cochlea was perfused with 10% neutral formaldehyde solution. The temporal bones were then removed and immersed in the fixative. After fixation the temporal bones were rinsed in running tap water, the bone of the otic capsule was thinned by means of a dentist's drill and the cochlear partition was isolated from the apex up to the hook region under a dissecting microscope. The whole spiral organ was stained in situ with toluidine blue and Ehrlich's haematoxylin. The method is described in detail elsewhere (Úlehlová & Voldřich 1987). The surface specimens of the basilar membrane were mounted in glycerol (see Burda et al. 1989). One cochlea of both species was decalcified by EDTA in toto, embedded in paraffin wax (FLUKA). Midmodiolar sections were cut at 15 micrometers thickness. To ascertain the mean basilar membrane width, five measurements were taken at every half-turn in the horizontal modiolar plane.

For quantitative assessment, the organ of Corti was divided into ten segments of equal length in the range of "1" to "10" with subdivisions of "1", with helicotrema being the starting point. All observations and measurements including the sensory stereocilia height assessment were made by light microscopy.

#### RESULTS

The cochleae of both species studied have 3 and 1/4 turns. The mean total length of the basilar membrane from apex to base including the hook region was  $25.88 \pm 0.91$  mm [N=11] and  $25.08 \pm 0.91$  mm [N=7] in the Vervet and the Macaque respectively (Tab. 1, Tab. 2). The basilar membrane width, measured in each successive half coil ranged from  $114.05 \pm 3.8$  to  $317.76 \pm 7.22$  micrometers in the Vervet and from  $114.88 \pm 3.61$  to  $315.84 \pm 4.65$  micrometers in the Macaque (Fig. 3).

The organ of Corti contained on average  $2493 \pm 108$  inner hair cells [IHC],  $9125 \pm 397$  outer hair cells [OHC] in the Vervet and  $2605 \pm 198$  IHC,  $9638 \pm 404$  OHC in the Macaque. This means that there are on average 96 or 104 IHC and 355 or 384 OHC per one millimeter of the spiral organ of Corti in the Vervet and the Macaque respectively (Tab. 1, Tab. 2).

In both primate species, OHC are arranged, as is usual in mammals, into three rows which tend to be more irregularly arranged at the apex than at the base (Figs 1 and 2)\*. OHC which could be classified as belonging to the fourth row were found only exceptionally.

The density of hair cells along the organ of Corti was not uniform. As far as OHC are concerned, their density decreased almost linearly from apex to base (Figs. 4 and 5) correspon-

\* The figures 1 and 2 will be found at the end of this issue.

Table 1 Basilar membrane length and hair cell counts in the Vervet Monkey (1 to 6 - numbers of the individuals involved, R, L - right or left ear)

individual/ /ear	BM length (mm)	Total HC	Total OHC
1/L	26.29	2458	9063
1/R	25.98	2516	9068
2/L	27.54	2605	9085
2/R	27.23	2604	9195
3/L	25.67	2361	8552
3/R	25.04	2280	8484
4/L	25.35	2533	9199
4/R	25.20	2516	9193
5/L	25.07	2451	9291
5/R	24.84	2452	9245
6/R	26.45	2644	10002
mean	25.88	2493	9125
Sd	0.91	108.5	396.7

ding to a continuous widening of the cuticular plates of OHC and flattening of the "W" pattern of the OHC stereocilia formation. On the contrary, in both species under study the density of IHC is apparently different and species specific. In the Vervet Monkey it decreases from the apex reaching its minimum value by the third and fourth segment, then it begins to rise again towards the base (with two cochleae of the animal No 3 being the exception) reaching a plateau of maximum density values from the fifth to the ninth segment. There is a slight depression in the IHC density curve apparent between the sixth and the seventh segment. It is, however, not present in all ears studied. Although the absolute number of IHC within respective segments varied in different individuals, the density distribution curves followed (with one above mentioned exception) a similar trend in all ears examined (Fig. 6). No difference between males and females has been found.

In the Stumptail Macaque the IHC density decreased steeply within three apical segments from 130-140 IHC/mm to 110 IHC/mm then the curve followed a moderate descending trend finally reaching about 95 IHC/mm at the base (Fig. 7).

Table 2 Basilar membrane length and hair cell counts in the Stumptail Macaque (1 to 4 - numbers of the individuals involved, R, L - right or left ear)

individual/ /ear	BM length (mm)	total IHC	total OHC
1/L	23.69	2538	9006
1/R	23.92	2517	9123
2/L	25.38	2752	9690
2/R	25.99	2828	10005
3/R	25.24	2690	9885
4/L	25.76	2233	9864
4/R	25.59	2679	9894
mean	25.08	2605	9638
Sd	0.91	197.8	404.1

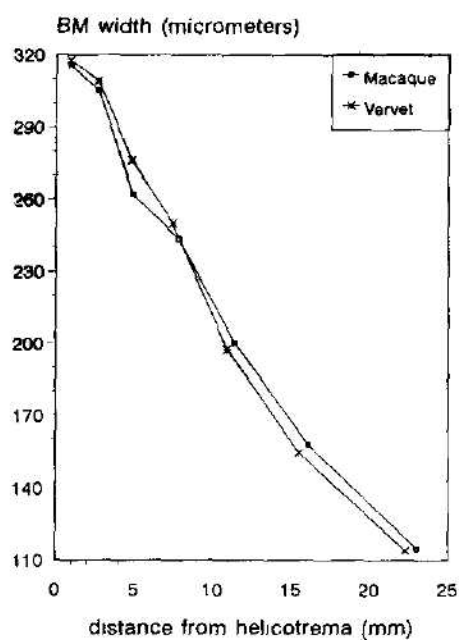


Fig. 3. Basilar membrane width.

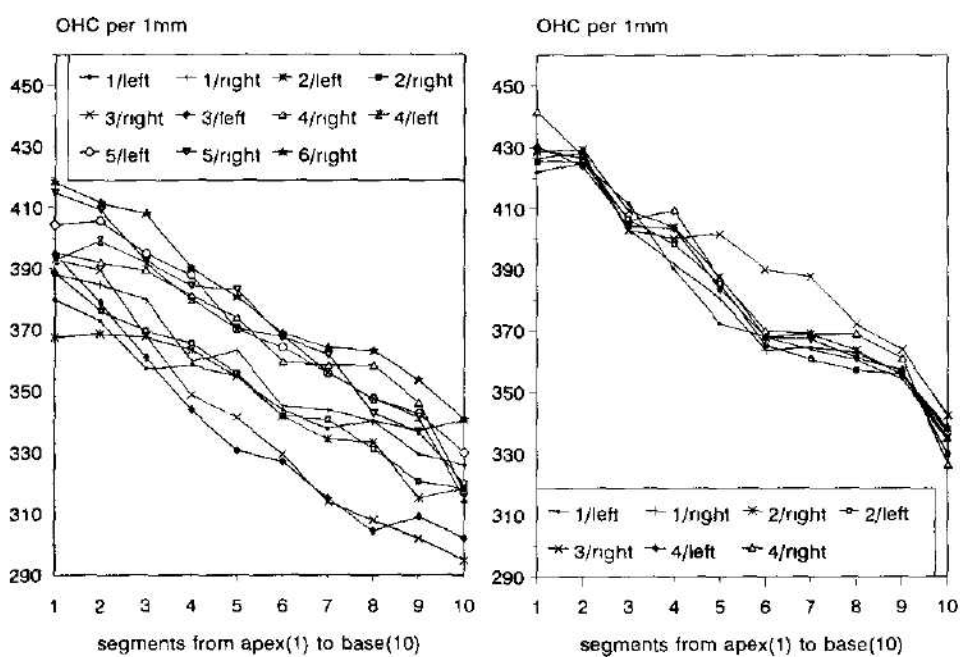


Fig. 4. Outer hair cell density per 1mm of the organ of Corti (Vervet Monkey).

Fig. 5. Outer hair cell density per 1mm of the organ of Corti (Stumptail Macaque).

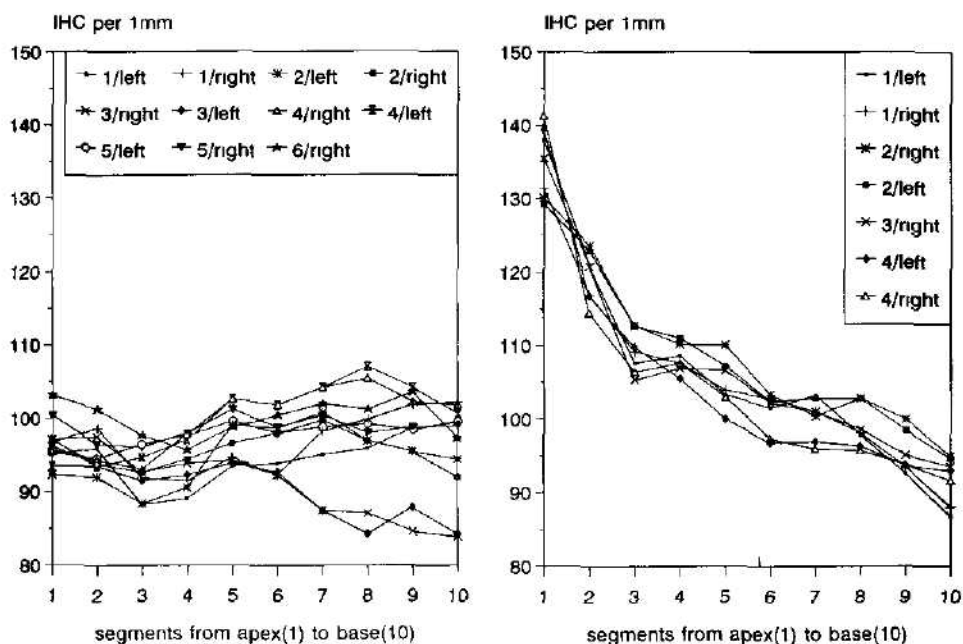


Fig. 6 Inner hair cell density per 1mm of the organ of Corti (Vervet Monkey).

Fig. 7. Inner hair cell density per 1mm of the organ of Corti (Stumptail Macaque).

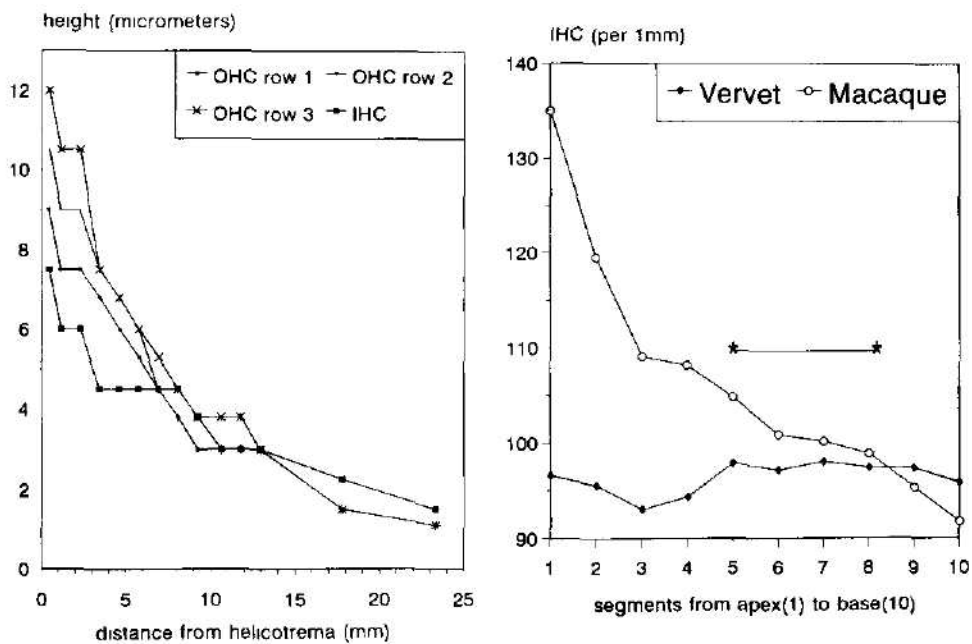


Fig. 8 Height of longest stereocilia in a given region (Stumptail Macaque - animal No. 3L)

Fig. 9 Average hair cell densities in the two primate species studied (asterisk region corresponds to higher sensitivity for frequencies between 1 and 8kHz as given by Stebbins 1973)

According to pilot measurements performed in one cochlea of the Stumptail Macaque the stereocilia bundle gradually decreased its height from apex to base with only a slight apical difference between four rows of hair cells with the third OHC row having the longest and the IHC having the shortest hairs (Fig. 8).

#### DISCUSSION

Number of cochlear coils in both species under study is 3 and 1/4. It is the maximum length recorded in primates. Similar values are given also for *Cebus albifrons*, *Ateles belzebuth* and *Papio papio* (Werner 1960). The width of the basilar membrane falls within the range known for other primate species which according to Werner (1960) is 105-158 micrometers at the base and 306-432 micrometers at the apex but does not reach the values given for man by Held (1926, quoted by Nadol, 1988), i.e. 104-504 micrometers. In comparison with values mentioned by Nadol (1988) for several mammalian species including man the longest hairs in the stereociliary tuft at the apical pole of hair cells are higher (longer) in the Stumptail macaque than in rat, guinea pig, cat and even in man. Nevertheless, in the monkey, the stereociliary bundle height increases apicalwards in a similar manner as in other mammalian species so far studied.

As mentioned already, OHC are distributed very regularly along the organ of Corti similarly in both monkeys. On the contrary, in the Vervet Monkey the density of IHC varies along the organ of Corti in a way which is seemingly different from that of the Stumptail Macaque. As evidenced and discussed in several mammalian species there are some striking correlations between the distribution of hair cells and the curves of auditory (sensitivity and/or resolution) thresholds. In contrast, such a relation does not exist in humans. We have tried to compare the determined morphometrical curve of the hair cell density distribution with the audiometrical pattern for four genera of the subfamily Cercopitheciinae, as described by Stebbins (1973).

The only correlation can be found in the region of maximum IHC density in the Vervet which roughly correlates with high sensitivity for frequencies above 1kHz (between segments 6 to 8). We have to point out, however, that the concordance between the distribution of the IHC density and the auditory threshold is not as obvious as in some smaller, subprimate mammals studied from this aspect. The OHC densities in both species and the morphometrical curve of IHC density distribution of the Stumptail Macaque cannot be correlated with the audiogram at all (Fig. 9).

The lack of complete correlation between the hair cell density distribution curve and the audiogram cannot be interpreted as showing that the (inner) hair cells are not involved in frequency discrimination, or that frequency discrimination is poor in the primates under study. Even in those segments where the hair cell density is lowest the actual total number of hair cells in a segment roughly corresponding to a frequency octave vibrating unit is comparatively high due to the longer organ of Corti.

A correlation between the auditory sensitivity for a given frequency region and the number of hair cells, which is a function of the cell density and the length of the corresponding segment, has already been pointed out for several mammalian species especially for those from lower nonprimate taxons such as rodents or bats (Ehret & Frankenreiter 1977, Burda & Voldřich 1980, Burda & Úlehlová 1983, Burda 1984, etc.) but was not proved in the present study for two primate species, the Stumptail Macaque and the Vervet Monkey. Tonotopically related hair cell density distribution is also not known in humans.

It is evident that the relation between the quantitative aspect of the cochlear hair cell population and the functional ability is not clarified enough and still requires further study.

### Acknowledgements

We are indebted to Doc Dr F. Jelfínek from ISV Prague, for supplying us with the specimens examined. The technical assistance of Miss Jolana Němcová is also acknowledged.

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## BOOK REVIEW

MELKONIAN M., ANDERSEN R. A. & SCHNEPT F. (eds) **The cytoskeleton of Flagellate and Ciliate Protists**. Wien - New York: Springer - Verlag, 1991, 167 pp., Cloth Price OS 1386 00, DM 198

This volume represents a special edition of "Protoplasma", Vol. 164, 1991. It was compiled by 20 international experts and consists of 13 chapters, which actually present individual scientific reports giving a good number of references to the primary literature. The purpose of report 1 on terminology and nomenclature of the cytoskeletal elements associated with the flagellar/ciliary apparatus in protists is to establish clear definitions, identify synonyms and indicate homologies. Included are 43 definitions of cytoskeletal elements, for example: paraxonemal structures, fibrillar surface coat, flagellar hairs, transitional region, concentric fibers, basal body, carbowheel, microtubular roots, haptonema etc. Report 2 deals with tubulin gene families in flagellate/ciliate protists. Report 3 demonstrates the transmembrane signaling as an important component of the function of cilian and flagellar surfaces. Following four reports are dedicated to the flagellar apparatus and swimming patterns of algal flagellates. In report 8 flagellar and cytoskeletal systems in amitochondrial flagellates *Archamoeba*, *Metamonada* and *Parabasal*, the so-called *Archezoa*, are examined. In spite of the lack of mitochondria the archezoan groups of protists show considerable differences in their organization. This report examines the characters of the flagellar apparatus and its associated cytoskeleton to obtain clues used for phylogenetic consideration of the three cited groups of flagellates. The data available in report 9 provide support for the hypothesis that euglenoids and kinetoplastids are more closely related to each other than they are to other protists. Ultrastructural comparison of the mitotic, feeding and flagellar apparatus, and cytoskeleton are investigated here. In following two reports a comparative overview of the flagellar apparatus and cytoskeleton of the dinoflagellates and descriptions of kinetic structure of the ciliate protists are given. Last two reports deal with ultrastructural aspects of algae and zoosporic fungi.

The cytoskeleton, intracellular network of protein filaments gives the cell strength, rigidity and shape, and it is responsible for cell motility and intracellular movements. Several monographs devoted to this cellular organelle have been published recently. This volume provides an up to date synopsis of the flagellar apparatus/cytoskeleton, illustrated by 154 high-quality, for the main part electron microscopic figures. It represents a valuable source of information for scientists who wish to become familiar with the morphology of protists and protozoan parasites.

*Jindřich Jirá*



## Chemostat-Turbidostat discontinuum, r-K continuum and population-size regulating mechanism

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**Evolution, selection, r-K strategy, turbidostat, chemostat, negative feedback loop, number regulating mechanism, model, efficiency of growth, rate of growth**

**Abstract.** The size stability of natural populations indicates that growth and mortality rates are on average equal. Fine tuning of the two independent processes suggests the existence of a regulating mechanism. Two types of such mechanisms exist. A decrease in the number of organisms can either speed up the growth rate or slow down the mortality rate. The former mechanism (chemostat like) acts whenever the growth is limited by the concentration of a resource. The latter (turbidostat like) could be suspected whenever the growth is limited by predators or parasites. Simulation experiments showed that under chemostat like and turbidostat-like conditions, organisms are selected toward efficiency of growth (gms of biomass produced/gms of resource consumed) and rate of growth (gms of biomass/time), respectively. The existence of two types of selection and the nature of parameters that are selected for, recall old idea of r-K strategies. The main difference is that while the old model predicts the existence of r-K continuum, this model shows that the two strategies are exclusive.

### INTRODUCTION

The idea of r and K strategies (r and K selection) is very popular among students of ecology. Originally r-selection meant selection for high population growth in uncrowded populations and K-selection referred to selection for competitive ability in crowded populations (MacArthur & Wilson 1967, Hairston et al 1970, Wilbur et al 1974). Later, however, the meaning of these terms was broadened (Pianka 1970, 1972, Southward 1977) and partially changed (Stearns 1976, 1977, Parry 1981).

Currently, r-strategists are considered those organisms that invest their reproductive effort into the production of a great number of offspring. Biological qualities of the offspring, reflected by the chance that individual will survive and reproduce, can be low. On the contrary, the K-strategists invest their reproductive effort into the production of fewer offspring with higher parental investment per capita. Consequently, the chance that an individual will survive and reproduce can be relatively high. The biological properties of r-strategists and K-strategists can also be characterized in concrete terms like body size, generation time, number of reproductive seasons during the lifespan (all lower in r-strategists), or by the effect of the strategy on the properties of the whole population. Populations of r-strategists fluctuate with time. Their size is usually lower than the maximal carrying capacity of the environment. Competition in such populations is low or nonexistent. The individuals are often eliminated from the population randomly, and there is only a low correlation between the biological qualities or the age of individuals and their actual probability of dying. The properties of populations of K-strategists are just the opposite.

r-strategy is often considered an adaptation for living in unstable or unpredictable environments, e.g., resource-rich ecosystems in the earliest stages of ecological succession. On the other hand, K-strategy is considered the optimal adaptation for living in stable or predictable environments, for old and crowded ecosystems in or near a climax stage.

The idea of r-K strategies was introduced by MacArthur. The names K and r have been derived from names of two parameters in the common form of the logistic equation

$$dN/dt = rN(1-N/K)$$

where  $r$  is the intrinsic growth rate of the population (under optimal conditions) and  $K$  is the carrying capacity of the environment (the size of population for which  $dN/dt = 0$ ).

The theory in its original formulation (MacArthur 1962), as well as its later development (MacArthur & Wilson 1967), suggests that the existence of two different strategies has something to do with the logistic equation-based model of population growth. As it has already been pointed out (Pianka 1972, Ginzburg 1992), this is not so. In the systems described by the logistic equation, both parameters  $r$  and  $K$  are simultaneously under pressure from natural selection. From the equation, it cannot be explained why two distinct ecological strategies, rather than a single mixed one, should exist. Moreover, the logistic equation represents a phenomenologic (descriptive) rather than mechanistic model. It is a rearranged second-order polynomial  $dN/dt = aN - bN^2$ . This function fits a S-shaped growth curve usually obtained in experiments, but it does not deal with the actual mechanism of growth and death in natural populations.

It can be concluded that despite the popularity of the r-K idea and despite the evident existence of two distinct ecological strategies, no theoretical model exists so far which could explain the r-K dichotomy phenomenon.

The present study attempts to show that the existence of two basic types of selection, and consequently two basic types of ecological strategies, can be explained by the existence of only two number-regulating mechanisms that can control the growth of a population. Because any population is subjected to one of these two mechanisms, it is also forced to adopt one of two exclusive life strategies.

## RESULTS

### Model of two types of number-regulating mechanisms

Despite the existence of temporal fluctuations, the long-term size of a population of different biological species is mostly stable. Such stability implies that natality and mortality rates in natural populations are essentially equal. Such fine tuning of two relatively independent processes in an unpredictable and fluctuating environment is not possible without a negative feedback loop-based number-regulating mechanism.

Basically, there are only two possibilities for the realization of such a mechanism. An increase (decrease) of population number must either induce a decrease (increase) in the natality rate or an increase (decrease) in the mortality rate. Regardless of the type of number-regulating mechanism, a size of the population exists, for which the natality and mortality rates are equal. Under normal conditions this equilibrium point is stable, i.e., after a disturbance the size of the population returns to its original value.

From ecological and evolutionary points of view there is an important difference between these two number-regulating mechanisms. It can be shown that the type of regulation mechanism determines which property of living systems actually contributes to their fitness, i.e., which is subjected to natural selection.

The mortality rate-regulation can be modeled in a laboratory turbidostat (a flow reactor). In this system for continuous cultivation of microorganisms, the population size is regulated by a negative feedback loop between population size (usually monitored by optical density of the

cultivation medium in a tank) and a rate of the pumping of medium through (and consequently a rate of the washing-out of the microorganisms from) the tank. The growth of microbes can be described by a differential equation

$$dN/dt = N (r - D N)$$

where  $N$ ,  $t$  and  $r$  are population size, time and growth rate (natality minus natural mortality per capita), respectively.  $D$  is a constant, a technical parameter of the turbidostat, which determines the rate of the pumping of the cultivation medium through the cultivation tank when population size is equal to one.

The second type of number-regulating mechanism operates in a chemostat. This system for continuous cultivation of microorganisms can be realized in any turbidostat by keeping the concentration of some growth factor in the inflow medium at very low limits. Under these conditions the growth of microorganisms and the dynamics of the concentration of the limiting component in the medium (limiting resource) can be described by.

$$\begin{aligned} dN/dt &= N (\text{Min}(r, R/Ik) - D N) \\ dR/dt &= D(S - R) - N \text{Min}(r/k, R/I) \end{aligned}$$

where  $R$  and  $S$  are concentrations of the resource in the cultivation tank and in the inflow medium, respectively,  $k$  is the growth efficiency (the number of individuals produced per units of resource consumed), and  $I$  is the rate of input of resource into one organism under conditions when  $R = 1$ . The meanings of all other symbols are the same as in the previous model. This proposed model differs from common models of the chemostat (Tilman 1982) in two respects. First, the proposed model is universal, it can operate in the chemostat, as well as in the turbidostat mode. Second, the growth of organisms is described by a non-smooth function  $\text{Min}(r, R/Ik)$ , rather than by a Monod's function  $rR/(R + K)$  (in Monod's function (Monod 1950) the  $K$  is a half-saturation constant, the concentration of resource at which growth rate reaches half its maximal value). The Minimum function is preferred in the present model, because it better reflects the behavior of real organisms. When the concentration of a resource increases the Monod function only asymptotically approaches a theoretical maximal growth rate. For real organisms, however, the maximum growth rate exists, which can be reached under the condition of optimal resource concentration but cannot be exceeded, no matter any further increase in the resource concentration (Peczurkin 1981).

In the proposed model four types of variables exist: 1) output variables ( $N$ ,  $R$ ), 2) technical parameters of the device ( $S$ ,  $D$ ), 3) elementary biological parameters of organisms ( $r$ ,  $k$ ) and 4) composite parameter of the organisms ( $I$ ). In contrast to the elementary parameters  $k$  and  $r$ , the composite parameter  $I$  cannot be a criterion of fitness. It represents either a physical constant reflecting the coefficient of diffusion of resource particles (Flegr 1990), or the result of a physiological regulation that optimizes the rate and efficiency of growth for a current resource concentration (Shinol 1979).

### Competition in turbidostatic and chemostatic systems

To study the competition in the number-regulated populations one must simulate the dynamics of a system of two different species (A and B). Such systems can be described by

$$\begin{aligned} dN_A/dt &= N_A (\text{Min}(r_A, R/Ik_A) - D (N_A + N_B)) \\ dN_B/dt &= N_B (\text{Min}(r_B, R/Ik_B) - D (N_A + N_B)) \\ dR/dt &= D (N_A + N_B)S - D(N_A + N_B)R - N_A \text{Min}(r_A/k_A, R/I) - N_B \text{Min}(r_B/k_B, R/I) \end{aligned}$$

One can analyze the competition of two species that differ in maximal growth rates as well as

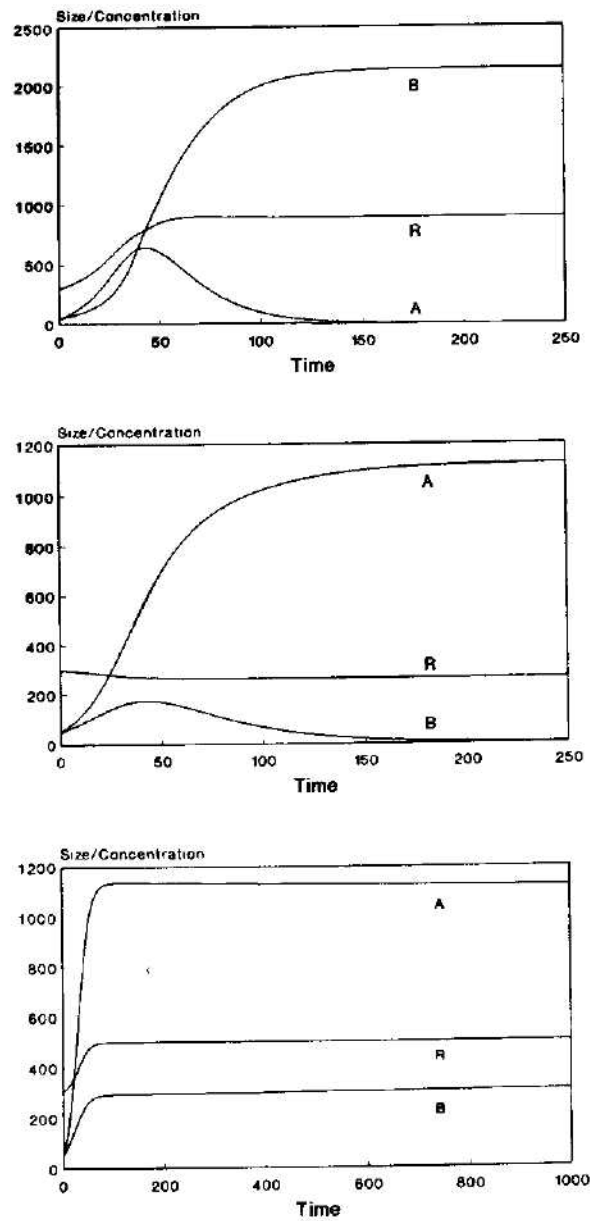


Fig.1. Simulation of the competition of two species, A and B under conditions of different concentrations of resource  $I$  in the inflow medium. The simulation was performed using the Biosimul C program (Pazourek, 1992), with parameters:  $D=0.00007$ ,  $I=0.00001$ ,  $r_A=0.1$ ,  $r_B=0.15$ ,  $k_A=30$ ,  $k_B=20$ ,  $N_A(0)=50$ ,  $N_B(0)=50$  and  $R(0)=300$ . Concentration of the resource in the inflow medium ( $S$ ) was 1000, 300 and 553 arbitrary units for Fig. 1a, 1b and 1c, respectively.

in efficiencies of growth. It is illustrative to suppose that species A has a higher maximal growth rate and lower efficiency of growth than species B. The result of numeric simulation of competition under conditions of different resource concentrations in the inflow medium is shown in Fig. 1. Evidently three different situations could occur:

1) When the concentration of the resource is low, the growth of both populations is regulated by the chemostatic mechanism. The species with lower efficiency of growth (species A) is completely displaced after an initial period of growth.

2) When the concentration of the resource is sufficiently high, the opposite situation occurs. Both populations are regulated by the turbidostatic mechanism, which results in the displacement of the population with lower maximal growth rate (species B) after the initial period of growth.

3) A range of concentrations of the resource also exists for which the population of species A is regulated by the chemostatic mechanisms while the population of species B is regulated by the turbidostatic mechanism. A long-term coexistence of two populations is then possible. During the period of coexistence, species A is being selected toward a higher efficiency of growth while species B toward a higher maximal growth rate. This selection could result either in the switching of the chemostatic regulation of population A to the turbidostatic, or in the switching of the turbidostatic regulation of population B to the chemostatic. After such an event, the second species is quickly displaced.

In summary, the chance of an organism's survival in interspecies competition is determined by two basic biological parameters (the maximal growth rate and the efficiency of the growth) and by the type of number-regulating mechanism in operation. It is also determined by the organism's capacity to improve these parameters in response to natural selection.

#### DISCUSSION

Results of our simulation experiments showed that under chemostat-like cultivation conditions, growth efficiency was the critical factor in the fitness of an organism and also a subject of natural selection. Under the turbidostat-like conditions the critical factor was the maximal growth rate.

It seems that in biological systems, even in the laboratory ones, a broad spectrum of properties of the organisms plays an important role in interspecies and intraspecies competition. For example, mutants that can adhere to the walls of the cultivation tank or that can replace part of the resource with another component of the medium will displace their competitors. Such mutations could be considered an improvement of maximal growth rate and an improvement of efficiency of growth in the turbidostat and the chemostat, respectively. Consequently, they will be selected for under both turbidostat-like and chemostat-like conditions. When the same mutation can be interpreted as the improvement of growth rate or growth efficiency according to the type of number-regulating mechanism in operation, the practical meanings of discrimination between the two basic parameters of growth (rate and efficiency) might be questioned.

The reason for such discrimination is that a category of mutations exists for which the improvement of the growth rate can be achieved only at the expense of the growth efficiency (and vice versa). The destiny of these mutations is determined by the type of number-regulating mechanism in operation. The trade-off between efficiency and rate could be a very common phenomenon in biological systems (Shnoll 1979). It means that these mutations can be numerous and their destiny could determine the life strategy of organisms and the character of evolution of the population or of the species.

The present model describes an artificial system for the continual cultivation of microorganisms. The chemostat-like as well as turbidostat-like types of number-regulating mechanisms

operate also in natural ecosystems. The chemostat-like mechanisms operate whenever the growth of population is being limited by an availability of some resource (energy, substance, space). The turbidostat-like mechanisms must be suspected whenever the growth of population is being limited by the activities of predators or parasites.

Real populations are continuously under influence from many factors. Their growth is controlled by the availability of different resources and by the activities of different predators. Their growth should be described by a general expression.

$$dN/dt = f(N^A, N^B, N^C, \dots, N^Z)$$

Here, more than one value of  $N$  can exist for which the  $dN/dt = 0$ . Some of these equilibrium points can be stable, some unstable. The population can move from one equilibrium point to another. At any moment, however, the population can be at only one equilibrium point. For any equilibrium point there are always principal components that are responsible for the return of the population size to the original value after a fluctuation, i.e., for the negative feedback loop. The character of these principal components determines what type of number-regulating mechanism is functioning at any particular equilibrium point.

When we look at the list of properties of  $r$ -strategists and  $K$ -strategists given in the Introduction or elsewhere (Pianka 1978, Parry 1981), we can see that the properties typical for  $r$ -strategists are always more or less tightly connected with maximization of the growth rate, while for  $K$ -strategists with the maximization of the efficiency of growth. It is also evident that  $r$ -strategists are typical inhabitants of resource-rich ecosystems while  $K$ -strategists of crowded ecosystems where the limitation by the unavailability of some resource can be observed or expected. This suggests that the  $r$ -strategists and the  $K$ -strategists could in fact be the organisms living under the turbidostat-like and chemostat-like conditions, respectively. The  $r$ -strategists are being selected toward a higher  $r$  (toward maximal growth rate) which forces them to adopt the  $r$ -maximizing strategies. At the same time, the  $K$ -strategists are being selected toward a maximal efficiency of growth (maximal  $k$ ) which forces them to adopt the  $k$ -maximizing strategy.

Three differences between  $r$ - $K$  and  $r$ - $k$  conceptions should be pointed out.

1) The  $r$ - $k$  conception predicts that the maximal growth rate and the efficiency of growth are being maximized during evolution in turbidostat and chemostat, respectively.

According to  $r$ - $K$  theory, parameters maximized are growth rate and carrying capacity of environment at the turbidostat and chemostat, respectively. From the results of simulation experiments it is evident, however, that the phenomenologically defined constant  $K$  (see the definition) is being maximized both in the turbidostat and the chemostat.

2) Ecologists usually suppose that instead of distinct  $r$  or  $K$  selection, the  $r$ - $K$  selection continuum normally exists (Pianka, 1978). Our results show that these two types of selection are not only distinct, but also exclusive. The  $r$ - $K$  continuum, which can be observed in nature, can rather be interpreted as the result of an existence of evolutionary constraints. Nobody doubts that horses will never change into bacteria-like organisms, no matter how strong  $r$ -selection they are being exposed.

3) The  $r$ - $K$  theory is based on empirical data only. There is no theoretical model that could explain the existence of these two types of selection. On the other hand,  $r$ - $k$  conception, which explains the same empirical data, was deduced from a mechanistic model of population growth.

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## BOOK REVIEW

MARKELL E. K., VOGEL M. & JOHN D. T. *Medical Parasitology*. Seventh Edition. W. B. Saunders Company, Harcourt Brace Jovanovich, Philadelphia, London, Toronto, Sydney, Tokyo 1992. X + 463 pages. Format 180 x 260 mm. Price hardcover Lstg 32.00. ISBN 0 7216 3411-7.

The leading author is Clinical Professor of Medicine and Tropical Medicine at the University of California, San Francisco. Unfortunately, the second author deceased in 1984. The third author is Professor of Parasitology at the Oklahoma State University, Tulsa.

The previous editions of this book appeared in print in 1958, 1965, 1971, 1976, and in 1986. As indicated in the preface, the major changes in the present edition are a number of new life-cycle drawings, additional illustrations for and rearrangements of the chapters on techniques, the addition of a number of new figures throughout the book, and a new chapter on the parasitic diseases associated with immune deficiencies. The volume is concluded with a comprehensive list of up-to-date references. Individual parasitic diseases are presented according to following scheme: morphology and biology of the causative agent, symptoms, pathogenesis, epidemiology, prevention, and treatment.

Chapter 1 contains the introduction to parasitology and basic information in the field. Chapter 2 provides insights into the phenomena of parasitism and host relations. Chapters 3-5 are concerned with protozoic parasites. Lumen dwelling (intestinal) protozoa are represented by the dysentery amoeba and other species of the genus *Entamoeba*, including the commensals. Listed here are representatives of the opportunistic free-living genera *Acanthamoeba* and *Naegleria*. Further on, the ciliates and apicomplexans, including the isosporans, sarcocysts, cryptosporidia, and microsporidia are discussed. Following chapters are dedicated to malarial plasmodia, leishmaniae, toxoplasmas, and to other blood and tissue-dwelling (histozoic) protozoa.

Chapters 6-9 comprise helminths as endoparasites in humans. The trematodes are represented by the giant intestinal fluke *Fasciolopsis buski*, by echinostomes, heterophyids, by liver flukes, blood flukes (schistosomes), and by different species of lung flukes belonging to the genus *Paragonimus*. Uncommon trematode parasites as species of *Alaria* and *Nanophyetus salmuncola* are also looked at here. The cestodes found in humans include the broad (fish) tapeworm, the pork and beef tapeworms, the agents of coenurosis and hydatid disease, and other tapeworms found in humans (genera *Dipylidium* and *Hymenolepis*). Further on intestinal, blood, and tissue nematodes that cause filarial infections, trichinellosis, visceral larva migrans, angiostrongylosis and gnathostomiasis, and some uncommon tissue nematodes as *Eustrongylides* sp. and *Baylisascaris procyonis* are looked at.

Chapter 10 concentrates on arthropods and human disease. Recorded are the itch mite, the hair follicle mite, mites of nonhuman hosts that cause irritating dermatitis and allergy, human lice, fly larvae that cause myiasis, and chigoe flea. Descriptions of pentastomes, injurious arthropods and arthropod vectors follow.

Chapter 11 focuses on parasitic infections in immunocompromised hosts. Listed here are organisms of uncertain taxonomic status (*Pneumocystis carinii*, *Blastocystis hominis*), particular species of sarcomastigophorans, apicomplexans, and microsporidia (*Encephalitozoon cuniculi*, *Enterocytozoon bieneusi*), and particular species of helminths and arthropods. Chapter 12 summarizes signs and symptoms of parasitic disease, and chapter 13 discusses pseudoparasites and pitfalls.

Chapters 14-16 deal with procedures described for parasite identification and laboratory confirmation of parasitic infections when discussing examination of stool specimens, examination of blood, other body fluids and tissues, sputum and urine, and immunodiagnostic methods. Given here are detailed prescriptions for fixatives and preservation solutions, stains and media for culturing protozoan parasites.

The text is extensively augmented by 259 figures composed of line drawings and photographs. They constitute individual life history stages of protozoan and helminthic parasites, arthropods of medical importance, biological cycles, electron micrographs, stereoscans, pathological changes in organs and tissues, medical imaging

(to be continued on p. 194)

## Small mammals (Insectivora, Rodentia) in the city of Prague: distributional patterns

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### Urban ecology, synurbization, island biogeography

**Abstract** Based on material consisting of 9765 specimens collected in 105 localities, we analyzed present distribution of 11 small mammal species in the territory of Prague. This material included original as well as literary data (published papers, unpublished final reports of inventory research in natural reserves, diploma theses, etc.) from the period 1960–1990. According to their distribution pattern, the species can be divided into following two groups: 1) *Crocodylus suaveolens*, *Apodemus sylvaticus*, *Mus musculus* and *Microtus arvalis* are widely distributed in the whole territory, including the city centre. These species are able to penetrate through built up areas. *M. musculus* is the only true commensal species inhabiting buildings throughout the year. *C. suaveolens* is an outdoor species with the exception of cold winter months in which part of its population is concentrated indoors. *A. sylvaticus* and *M. arvalis* are not directly associated with human settlements, although the former species was found as winter immigrant into buildings. *A. sylvaticus* colonized almost all parks and other green areas in the city and become the most abundant species. Urban populations of both *C. suaveolens* and *A. sylvaticus* may probably gain owing to the absence of their potential competitors. *Microtus arvalis* is dependent upon presence of grassy plots. 2) Other species could be arranged into following array according to their decreasing ability to penetrate into the centre of the city: a) *Sorex araneus*, b) *Clethrionomys glareolus*, c) *Apodemus flavicollis*, d) *Sorex minutus*, *Neomys fodiens* and *Micromys minutus*. Absence of these species in suitable habitats in the parks and cemeteries surrounded by built up areas should be attributed to island effects. *Myomys subterraneus* is distributed in the southeastern part of the Prague territory only, because a local limit of its range in Central Bohemia passes just through Prague area.

### INTRODUCTION

Animal populations living in large urban agglomerations may serve as proper model in ecological studies (Klausnitzer 1987).

So far, little attention was devoted there to small mammals other than rats and house mice.

In Europe, certain data on their distribution and ecology are available from, e.g., Manchester (Yalden 1980), Oxford (Dickman 1987, Dickman & Doncaster 1986), Leipzig (Klenke 1986), Berlin (Eilers & Eilers 1984), Warsaw (see below), Wrocław (Chudoba et al. 1961), Košice (Možanský 1985), Poltava (Gavrilenko 1970), etc. Unfortunately, only few of these studies are based on numerous material. This fact was in most cases caused by frequent disturbance of traps by humans, forcing researchers to limit samples or to use alternative methods (Dickman 1986). The most comprehensive data were collected by Polish authors who systematically studied synurbization processes in *Apodemus agrarius* in Warsaw (Andrzejewski et al. 1978, Babinska-Werka 1981, Babinska-Werka & Gabarczyk 1981, Babinska-Werka et al. 1979, 1981, Gebczynska et al. 1987, Głowicz 1980a,b, Goszczynski 1979, Sikorski 1982a,b).

There are also papers dealing with ecology of small mammals in urban agglomerations in Central Asia (Alma-Ata: Stogov 1988), Japan (Takatsu 1976), and North America (Syracuse: VanDruff & Rowse 1986).

In the Czech Republic the occurrence of small mammals has been studied in the towns: České Budějovice (Vlček 1979, Vlček & Kohn 1986), Brno (Pelikán et al. 1980, 1983) and Liberec (Horová 1987).

In Prague, the systematical study of small mammal fauna started in the 1970s. Several papers about occurrence of small mammals in some parts of Prague have been published (Hodková 1981, Hanzal 1982, Korbová 1985b, Anděra 1987a,b, Vohralík & Řeháková 1985, Frynta & Vohralík 1991), single records are to be found also in publications by Grundová (1962), Vlasák (1969) or in theses by Trpák (1964) and Šmaha (1969), but most of data remained unpublished. Reviews of the that time knowledge were repeatedly given by Hanák (1975, 1976, 1983, 1985). Recently, attention was also paid to the reproduction and population structure in *Crocidura suaveolens* (Vohralík 1988) and *Apodemus sylvaticus* (Frynta 1992, 1993, Frynta & Vohralík 1992, 1994, Frynta & Žižková 1994).

The major aims of the present study are as follows:

1) Hitherto, a great number of records concerning the distribution of small mammals in the city of Prague have been accumulated. Despite their potential value, most of them remained just in field notebooks, some are available in unpublished theses or have been published in obscure journals. Therefore, we attempted to arrange all these scattered records into a single data set useful for further analysis.

2) A second aim is concerned with basic analysis of the distribution pattern in individual species. It is based on the evaluation of both the resulting distribution pattern and the situation in individual localities. This approach is suitable for solving the following topics: a) To classify the species according to their ability to penetrate into urban environment; b) To ascertain the species which have successfully colonised urban environment (indirect evidence for synurbization processes); c) To disclose the cases in which the species in a locality isolated by built up areas is absent, in spite of the presence of an apparently suitable habitat (indirect evidence for island effects).

A quantitative analysis of presented data will be given later.

#### MATERIAL AND METHODS

We attempted to collect all the available records on the distribution of small mammals in the territory of Prague starting from the 1960s until the year 1990. Our attention was restricted to species which could be studied using snap-traps of common size (10 x 5 cm). Distribution of larger, fossorial and/or arboreal species as *Arvicola terrestris*, *Talpa europaea*, *Glis glis*, *Muscardinus avellanarius*, *Rattus norvegicus*, etc., will be elaborated separately.

Most of the records is based on material collected by the first two authors (D. F., V. V.) and their colleagues and students from the Department of Zoology, Charles University, Prague. Some of the records were published (Vohralík & Řeháková 1985, Korbová 1985b, Vohralík 1988, Frynta & Vohralík 1992) or are available in unpublished theses (Čiháková 1989, Fridrich et al. 1989, Frynta 1982, Geussová 1989, Korbová 1985, Koblíková 1989, Zemanová 1986).

These data were complemented by an extensive inventory research in Natural Reserves in 1986-1989, which was supported financially by the Prague Centre of State Conservation Care and Nature Protection and organized by the last author (J. Ř.). Results of this research are given in a series of unpublished reports (Anděra 1986, 1989, Anděrová 1987, Horáček & Hošek 1988, Horáček et al. 1987, Hyniová 1987, 1988, Jarešová 1988, Řezníček 1988, Šimek 1987, 1988a,b, Šimek & Malina 1987, Smrček 1988, Švecová 1988, 1989). Faunistic records concerned with the period 1960-1990 contained in the literature were used also. Data obtained by raptor and/or owl pellet analysis were omitted because of the facts that the birds of prey are able freely cross the barriers of mammal migration and their foraging ranges can largely exceed the scale used in our mapping.

Altogether, we collected records of 9765 specimens belonging to 11 species (see below under Survey of the Material). Almost all this material, regardless to its origin was collected using small snap-traps (10 x 5 cm). Majority of these specimens were finally deposited in the collections of the Department of Zoology, Charles University, Prague. Only small, unimportant part of animals was collected in wooden live traps. These animals were immediately released or maintained in captivity. In several cases the findings of dead animals or nest records (in *Micromys minutus* only) were also included.

In a total, data on the distribution of small mammals in 105 localities were evaluated. These localities are distributed on the whole territory of the city of Prague (Fig. 1). In two localities (No 4 Bohnice housing estate, No 46 Riegrový sad), no animal were obtained in spite of trapping efforts exceeding 200 trap nights.

Most of animals were captured in green areas, e.g., parks, gardens, woods, cemeteries, ruderal sites, etc. Some of these plots (parks or cemeteries), situated in the center of the city, were almost completely surrounded by built up areas (localities Nos. 44, 46, 47, 49, 54, 88, 89, 91, 92, 94, 96). On the other hand, some other localities (woods, reserves) on the outskirts of Prague consisted of rather seminatural habitats (above all localities Nos. 1, 3, 13, 15, 16, 17, 18, 23, 24, 25, 26, 28, 30, 32, 33, 34, 35, 38, 66, 67, 70, 72, 99, 100, 101, 102, 103, 105).

Material from following localities was captured either exclusively (Nos. 7, 29, 45, 50, 51, 52, 53, 55, 57, 58, 59, 65, 90) or prevalingly (Nos. 6, 22, 27, 37, 54, 75, 85, 104) or partly (Nos. 5, 9) inside buildings.

In the distributional maps (Figs 2-12) we accepted even a single record as an evidence of presence of the species. Absence of the individual species was recorded in such localities only from which sufficient sample was available. As sufficient we considered samples either consisting of more than 75 specimens of small mammals (localities Nos. 5, 9, 12, 13, 15, 16, 18, 19, 25, 26, 28, 31, 32, 34, 35, 36, 38, 40, 47, 54, 61, 66, 67, 70, 72, 73, 78, 83, 84, 86, 88, 96, 99, 102, 105) or obtained using trapping effort of more than 1000 trap-nights (Nos. 3, 17, 44, 49, 94). Altogether, 40 localities were involved.

## SURVEY OF THE MATERIAL

In the following survey the individual species are arranged in their systematic order.

### *Sorex araneus* Linnaeus, 1766

1. Dražanské údolí, 1989, Stopka, 2. Bohnice, June 1989, 1 spec., Novotná, Bohnice - Vltava river bank, Nov 1989, 2 spec., Stopka, 3. Podhoří, Sept 1988, 3 spec., Oct 1989, 1 spec., 1 uch., 5. Zoopark, Feb 1976, 1 spec., Nov 1976, 3 spec., March 1977, 3 spec., May 1980, 2 spec., Řeháková, March 1982, 2 spec., Dámcová, Aug 1982, 4 spec., Dámcová, Vohralík, Oct 1982, 1 spec., Fuchs, Oct 1983, 8 spec., Frynta, Feb 1984, 1 spec., Dámcová, Oct 1984, 1 spec., Dec 1985, 1 spec., Frynta, 6. Troja, Sept 1974, 1 spec., Honcová, Oct 1979, 1 spec., Hodková, 12. Chabry, Oct 1989, 3 spec., Frynta, Zelinkova, 13. Dáblický hřbitov, April 1988, 6 spec., Vohralík, Novotná, April 1990, 6 spec., Vohralík, Cibulková, May 1989, 1 spec., Aug 1989, 1 spec., Vohralík, 15. Satalická bažantnice and Vinorský park, Dec 1987, 2 spec., Jan 1988, 1 spec., Feb 1988, 3 spec., (Čiháková 1989), Feb 1988, 1 spec., (Šmrček 1988), June 1988, 13 spec., (Čiháková 1989), June 1988, 2 spec., July 1988, 7 spec., (Šmrček 1988), Aug 1988, 9 spec., Sept 1988, 20 spec., Oct 1988, 14 spec., May 1989, 1 spec., Nov 1989, 4 spec., Nov 1990, 1 spec., (Čiháková 1989), 16. Klánovice - Vidrholc, June 1988, 3 spec., July 1988, 1 spec., (Švecová 1988), June 1989, 8 spec., (Švecová 1989), 17. Klánovice - Blatov, Dec 1987, 6 spec., Aug 1988, 1 spec., Nov 1988, 2 spec., (Řezníček 1988), 18. Xaverovský háj, 1987, 9 spec., (Šimek, Malina 1987, Šimek 1988b), July 1988, 1 spec., (Šimek 1988b), 19. CHU V Pískovně, 1987, 9 spec., (Šimek 1987, 1988a), July 1988, 5 spec., (Šimek 1988), 21. Malešice, March 1982, 3 spec., Chvojka, 23. Dubeč, Nov 1984, 3 spec., (Anděra 1987a), 24. Královice, Oct 1984, 6 spec., (Anděra 1987a), 25. ČHPV Mýto - Nedvězí, 1987-88, 22 spec., (Anděra 1989), 26. Uhřetěves - Obora, 1987, (Hymová 1987), Nov 1990, 2 spec., Musil, 27. Uhřetěves, Jan 1981, 1 spec., Červený, 28. Kolovraty, Nov 1989, 2 spec., Nov 1990, 3 spec., Škrle, 30. SPR Pitkovická strán, 1987-88, 2 spec., P Hanák, 31. Petrovice - along Botič stream, above the dam, April-Nov 1979, 15 spec., Hanák, Pražan, Hodková (Anděra 1987b), Petrovice - vicinity of Fantův mlýn, March 1980, 9 spec., Jan Febr 1981, 6 spec., Hodková, 32. Milčůvský les, March 1985, 1 spec., April 1985, 4 spec., (Zemanová 1986), 1986-87, 89 spec., (Anděrová 1987), 33. Újezd - along Botič stream, June 1988, 2 spec., Král, Nov 1979, 2 spec., Hodková, 34. Pruhonice, Oct 1979, 7 spec., Hodková, Nov 1989, 2 spec., Sádlo, 35. Pruhonice park, Sept 1983, 1 spec., Oct 1983, 1 spec., May 1984, 1 spec., Sept 1984, 1 spec., (Korbová 1985), 36. Hrnčíř, May 1983, 3 spec., (Anděra

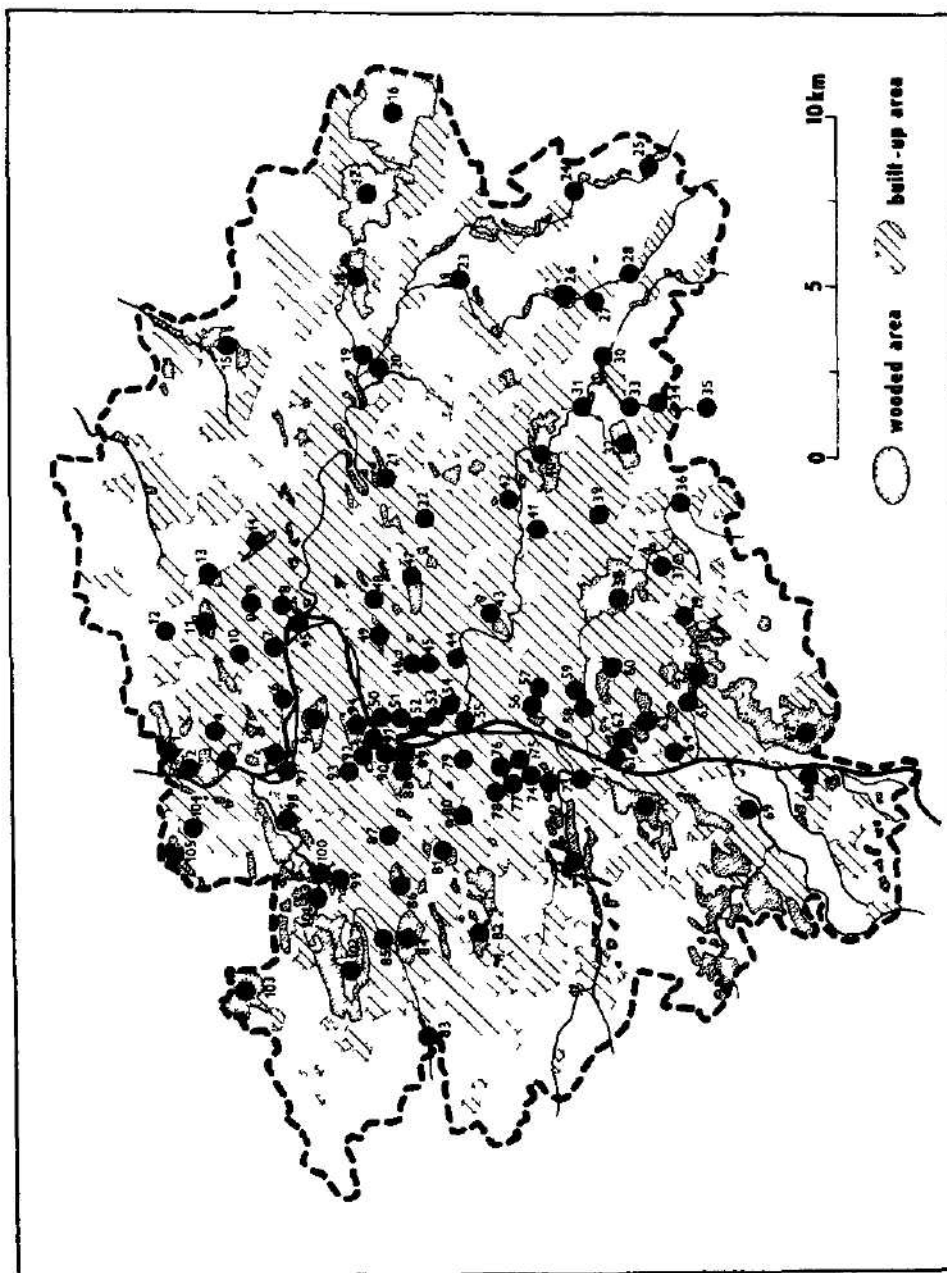


Fig. 1 Map of Prague with survey of localities where small mammals were collected. For locality names see under "Survey of the material"



1987a), Hrněšské louky, April 1987, 4 spec., May 1987, 1 spec., Oct 1987, 8 spec., (Horáček et al 1987), **37.** Kunratic, Jan 1982, 1 spec., Velčev; **38.** Kunratický les, April 1980, 1 spec., Hora, Frynta, March 1981, 1 spec., April 1981, 2 spec., Aug 1981, 6 spec., Oct 1981, 1 spec., Hora, Oct 1984, 2 spec., Vohralík, Průchová, Nov. 1984, 1 spec., Kulich; May 1985, 4 spec., Vohralík, Oct 1985, 1 spec., Zemanová, May 1986, 1 spec., Sept. 1986 1 spec., Horová, Sept 1986, 1 spec., Šálek, Oct 1986, 3 spec., Weidinger; Oct 1986, 1 spec., Šálek, Oct. 1987, 4 spec., (Horáček et al 1987); Oct 1987, 2 spec., Weidinger, Oct 1987, 1 spec., Vohralík, Geussová; May 1989, 2 spec., Voříšek, July 1989, 5 spec., Vohralík, Koroljeva, Škrle, **40.** Hostivař - along Botič stream, Sept. 1982, 4 spec., Frynta, Hostivař - SPR Meandry Botiče, Aug.-Oct. 1985, 6 spec., (Anděra 1987b), **48.** Ohrada, Nov. 1989, 1 spec., Exnerová, **61.** Braník, May 1986, 3 spec., July 1986, 2 spec., Aug 1986, 3 spec., Sept 1986, 3 spec., Oct. 1986, 2 spec., Nov 1986, 1 spec., Aug 1988, 4 spec., (Koblicová 1989), **62.** Hodkovičky, 1980 1 spec., Hodková; **63.** V lučinách street, Sept 1982, 2 spec., Nov. 1990, 1 spec., Frynta; **66.** Modřany, March 1980, 3 spec., Hanzák, Pražan, Hodková (Anděra 1987a); Modřanská rokle, Aug. Sept 1988, 2 spec., (Horáček, Hošek 1988); Nov 1990, 13 spec., Zelinková, **70.** Chuchelský háj, Sept 1988, 1 spec., Oct. 1988, 1 spec., (Hyniová 1988); Dec 1988, 5 spec., Jan 1989, 4 spec., Feb 1989, 2 spec., (Fridrich et al 1989), **72.** Klukovice - Holyně - along Dalejský stream, Dec. 1980, 1 spec., Sádlo, Švecová, Nov. 1989, 1 spec., Benda; May 1989, 1 spec., Aug 1989, 1 spec., Benda, Aug 1990, 1 spec., Frynta, Zelinková, Stopka, SPR Prokopské údolí - along the stream, 1983-86, 6 spec., (Anděra 1986), **73.** SPR Prokopské údolí (Butovická cesta - Bašta - Děvín), 1983-86, 42 spec., (Anděra 1986), **74.** Prokopské údolí (Bašta - Dlouhý hřbet), 1983-86, 12 spec., (Anděra 1986), **75.** U dívčích hradů, July 1986, 1 spec., Sigmund; Prokopské údolí, June 1986, 6 spec., (Anděra 1986), **78.** Malvazinky, May 1989, 1 spec., Exnerová; **80.** Šalamounka, March 1982, 5 spec., Frynta; **82.** CHÚ U Hájů, Dec. 1988, 6 spec., Jan. 1989, 18 spec., (Fridrich et al 1989); **83.** Ruzyně - Hostivice, Oct 1986, 6 spec., Dec 1987, 7 spec., Stopka; April 1989 1 spec., Stopka, Frynta, Zelinková, Nov 1990, 4 spec., Stopka, Vykopalová, Černý; **84.** Hvězda, Nov 1969, 1 spec., Slavíček; May 1981, 1 spec., Hora; Aug 1981, 2 spec., Aug 1982, 20 spec., July 1983, 13 spec., Dec 1984, 1 spec., Sept 1987, 16 spec., Frynta, May 1989, 1 spec., Vykopalová, Moravany street, Aug. 1990, 1 spec., Vykopalová, **96.** Stojanovka, Nov 1980, 1 spec., July 1981, 1 spec., Feb 1982, 1 spec., Oct 1985, 2 spec., Frynta; **97.** Císařský ostrov, March 1982, 2 spec., Frynta; **98.** Baba, Nov. 1989, 1 spec., Kodým, **99.** Arabská, May 1988, 1 spec., July 1988, 6 spec., Nov 1988, 2 spec., Jan 1989, 5 spec., April 1989, 1 spec., May 1989, 2 spec., July 1989, 1 spec., Sept 1989, 1 spec., Oct 1989, 1 spec., Jarešová; **101.** Tichá Šárka, May 1989, 1 spec., Kozlová, **102.** Divoká Šárka, April 1980, 2 spec., Hodková, Sept 1981, 8 spec., Hora, Oct 1981, 1 spec., Braniš, Sept 1982, 8 spec., Frynta; Sept 1988, 5 spec., Frynta, Kodejšová, Sept 1989, 4 spec., Frynta, Vykopalová, May-July 1988, 3 spec., (Jarešová 1988); **103.** Přední Kopanina, May 1989, 2 spec., Bílý, **105.** Tiché údolí, Sept 1982, 2 spec., Frynta, Nov 1986, 2 spec., Stopka; May 1989, 1 spec., Storch, Nov 1990, 1 spec., Kozlová

#### *Sorex minutus* Linnaeus, 1766

**15.** Satalická bažantnice and Vnořský park, June 1988, 1 spec., July 1988, 3 spec., (Šmrček 1988), **16.** Klánovice - Vidrholce forest, June 1989, 2 spec., (Švecová 1989), **17.** Klánovice - Blatov forest, Dec 1987, 1 spec., (Rezníček 1988); **18.** Xaverovský háj, July 1988, 1 spec., (Šimek 1988), **23.** Dubeč, Nov. 1984, 1 spec., (Anděra 1987a); **24.** Královice, Oct. 1984, 1 spec., (Anděra 1987a); **25.** CHPV Mýto - Nedvězí, 1987-88, 13 spec., (Anděra 1989); **31.** Petrovice - along Botič stream, above the dam, April-Nov. 1979, 7 spec., (Anděra 1987b), vicinity of Fantův mlýn, March 1980, 3 spec., Feb March 1981, 2 spec., Hodková, **32.** Milčovský les, March 1985, 1 spec., April 1985, 1 spec., May 1985, 1 spec., (Zemanová 1986); Oct 1985, 1 spec., Frynta, 1986-87, 17 spec., (Anděrová 1987), **34.** Pruhořnice - along Botič stream, Oct 1979, 5 spec., Hodková **35.** Pruhořnice park, Nov 1983, 1 spec., Frynta; **36.** Hrněš, May 1983, 3 spec., (Anděra 1987a), Hrněšské louky, 1987, 7 spec., (Horáček et al. 1987), **38.** Kunratický les, June 1962, 1 spec., V. Hanák, May 1980, 2 spec., Hodková, **66.** Modřanská rokle, Aug.-Sept. 1988, 1 spec., (Horáček, Hošek 1988); Nov 1990, 2 spec., Zelinková, **72.** SPR Prokopské údolí - along Dalejský stream, 1983-86, 1 spec., (Anděra 1986); Klukovice and Holyně - along Dalejský stream, May-Aug 1989, 1 spec., Benda, **99.** Arabská street, July 1988, 1 spec., Dec 1988, 1 spec., April 1989, 2 spec., Jarešová, **102.** Divoká Šárka, Sept. 1988, 2 spec., Frynta, Kodejšová, Holá, Sept. 1989, 1 spec., Frynta, Vykopalová

*Neomys fodiens* Pennant, 1771

1. Drahanské údolí, 1989, Stopka (in verb), 19. CHÚ V Pískovně, 1987, 2 spec, (Šimek 1987, 1988a), 23. Dubeč, Nov 1984, 1 spec, (Anděra 1987a), 24. Královice, Oct 1984, 3 spec, (Anděra 1987a), 25. CHPV Mýto Nedvězí, 1987-88, 2 spec, (Anděra 1989), 26. Uhlíněves - Obora, Nov 1990, 1 spec, Musil, 30. CHÚ Pitkovická stráž, 1987-88, 2 spec, P Hanák, 32. Milčevský les, 1986-87, 3 spec, (Anděrová 1987), 38. Kunratický potok (stream), (Šmaha 1969), 63. V lučinách, Sept 1982, 5 spec, Frynta, 66. Libušský potok (stream), (Šmaha 1969), 72. Klukovice and Holyně - along Dalejský stream, Dec 1980, 2 spec, Sádlo, Švecová, June 1989, 2 spec, Stopka, SPR Prokopské údolí - along Dalejský stream, 1983-86, 3 spec, (Anděra 1986), 83. Ruzyně - Hostivice, Oct 1986, 2 spec, Dec 1987, 1 spec, Stopka, 102. Divoká Šárka, Sept 1988, 12 spec, Frynta, Kodejšová, Sept 1988, 2 spec, Frynta, Vykopalová, May-July 1988, 6 spec, Jarešová, May-June 1989, 5 spec, Stopka, 105. Tiche údolí, 1984, 1 spec, Stopka

NOTE After finishing of the manuscript an additional record became available, that should not be omitted, i.e., 15. Satalická bažantnice and Vinořský park, Sept 1992, (Čiháková 1994)

*Crocivura suaveolens* (Pallas, 1821)

2. Čimice, Nov 1989, 2 spec, Stopka, 3. Podhoří, Sept 1988, 6 spec, Fuchs, 5. Zoopark, (Vlasák 1972), July 1974 - Dec 1985, 42 spec, (for details see Vohralík 1988), Oct 1983, 9 spec, Oct 1984, 2 spec, Nov 1984, 2 spec, Dec 1985, 5 spec, Frynta, Oct 1987, 3 spec, Frynta, Zelinková, Dec 1987, 4 spec, Frynta, Žižková, 6. Troja, Aug 1974, 1 spec, Honcová, Nov 1979, 2 spec, Hodková, U Vltavy street, Jan 1984, 1 spec, Dámceva, May 1989, 1 spec, Marks, 9. Davidkova street 74, 1969-87, 131 spec, (for details see Vohralík 1988), 10. Jodasova street 1077, Dec 1985, 1 spec, Hanzal, 12. Chabry, Oct 1989, 7 spec, Frynta, Zelinková, 13. Dablický hřbitov, May 1989, 1 spec, Vohralík, 15. Satalická bažantnice and Vinořský park, Sept 1988, 7 spec, (Čiháková 1989), 19. CHÚ V Pískovně, 1987, 5 spec, (Šimek 1987, 1988), 26. Uhlíněves - Obora, Oct 1986, 1 spec, Hodková, 27. Uhlíněves, Jan 1968, (Anděra, Hůrka 1984, Jan 1977, 1 spec, Sept 1977, 8 spec, Červený, 31. Petrovice - along Botič stream, above the dam, April-Nov 1979, 1 spec, (Anděra 1987b), 34. Průhonice - along Botič stream, Oct 1979, 1 spec, Hodková, 35. Průhonice - park, Sept 1984, 3 spec, (Korbová 1985), 36. Hmčev, May 1983, 1 spec, (Anděra 1987a), 38. Kunratický les, May 1980, 2 spec, Hodková, Nov 1984, 2 spec, Kulich, Sept 1985, 1 spec, Vohralík, Oct 1987, 1 spec, (Horáček et al 1988), Oct 1987, 1 spec, Weidinger, May 1989, 1 spec, Voříšek, 39. Saudkova street, Jan 1987, 1 spec, Horová, 40. Hostivar - SPR Meandry Botice, Aug-Oct 1985, 6 spec, (Anděra 1987b), May 1990, 1 spec, Zelinková, 41. Na chodovci street, Dec 1982, 1 spec, Špinar, 42. Zahradní Město, Sept 1982, 4 spec, Frynta, 47. Stránské židovské hřbitovy, Aug 1982, 8 spec, Frynta, May 1989, 28 spec, Nov 1989, 4 spec, Jun 1990, 3 spec, Kopský, Nov 1990, 8 spec, Exnerová, 49. Vítkov, Sept 1980, 3 spec, Frynta, 56. Na Kavčích Horách street, Feb 1986, 1 spec, Škopek, 61. Braník, Nov 1970, 2 spec, Zbytovský, April 1986, 2 spec, May 1986, 2 spec, Sept 1986, 1 spec, Nov 1986, 1 spec, (Koblicová 1989), Hodkovičky - near Vltava river, Nov-Dec 1986, 5 spec, Hodková, Braník, Aug 1987, 1 spec, Sept 1987, 1 spec, April 1988, 1 spec, Aug 1988, 5 spec, Sept 1988, 1 spec, Oct 1988, 1 spec, (Koblicová 1989), 64. Nad vinicí street, March 1980, 1 spec, Hodková, 68. Zbraslav, 1989, Hrdý (in verb), 69. Radotín, Nov 1986, 2 spec, Hodková, 70. Chuchelský háj, Dec 1988, 1 spec, (Fridrich et al 1989), 71. Pod Habrovou, Jan 1974, 1 spec, Špinka, 72. Klukovice and Holyně - along Dalejský stream, May 1989, 1 spec, Aug 1989, 1 spec, Benda, SPR Prokopské údolí - along Dalejský stream, 1983-86, 1 spec, (Anděra 1986), 73. SPR Prokopské údolí (Butovická cesta - Bašta - Děvín), 1983-86, 37 spec, (Anděra 1986), 74. SPR Prokopské údolí (Bašta - Dlouhý hřbet), 1983-86, 10 spec, (Anděra 1986), 76. Pod Kesnerkou, June 1988, 1 spec, (Geussová 1989), 78. Na Farkáně, March 1988, 9 spec, Sept 1988, 4 spec, V Hanák, Malvazinky, May 1989, 1 spec, Exnerová, Nov 1989, 1 spec, Vykopalová, 80. Šalamounka, March 1982, 1 spec, Frynta, 82. CHÚ U Hájů, Dec 1988, 1 spec, (Fridrich et al 1989), 83. Ruzyně - Hostivice, Oct 1986, 3 spec, Dec 1987, 3 spec, Stopka, 84. Hvězda, Nov 1969, 4 spec, Slavíček, May 1981, 1 spec, Hora, Aug 1981, 1 spec, Aug 1982, 3 spec, Frynta, May 1989, 1 spec, Vykopalová, July 1989, 1 spec, Frynta, Stopka, Exnerová, 85. Rybníčná street 17, Feb 1985, 2 spec, Sept 1987, 1 spec, Oct 1987, 1 spec, Jan 1989, 1 spec, Nov 1989, 1 spec, Pokorný, 86. Marketa, March 1982, 7 spec, Aug 1982, 1 spec, Frynta, April 1986, 1 spec, Frynta, Vohralík, Koblicová, May 1989, 1 spec, Mančíková, Nov 1989, 1 spec, Voříšek, 88. Petřín, Sept 1981, 1 spec, Sept 1987, 5 spec, Frynta, 92. U letohrádku královny Anny street, Feb 1984, 2 spec, Křepelová, 94. Letenské sady, Nov 1989, 1 spec, Sálék, 95.



Libeňský ostrov, Sept 1984, 2 spec, Frynta, Kubečka, **96.** Stromovka, June 1980, 1 spec, Aug 1980, 5 spec, Nov 1980, 3 spec, June 1981, 1 spec, Aug 1981, 1 spec, Aug 1982, 1 spec, Nov 1983, 3 spec, Frynta, **97.** Císařský ostrov, Feb 1980, 2 spec, Hodková, March 1982, 1 spec, Frynta, **99.** Arabská street, Jan 1988, 4 spec, May 1988, 1 spec, July 1988, 3 spec, Aug 1988, 1 spec, Nov 1988, 2 spec, Dec 1988, 4 spec, Jan 1989, 1 spec, June 1989, 1 spec, July 1989, 1 spec, Oct 1989, 1 spec, Nov 1989, 1 spec, 1989, 1 spec, Jan 1989, 1 spec, Feb 1990, 2 spec, Jarešová, **101.** Jenerálka, June 1990, 1 spec, Jarešová, **105.** Tiché Udolí, Nov 1990, 1 spec, Kozlová

### *Clethrionomys glareolus* (Schreber, 1780)

**1.** Dražanské údolí, May 1989, 3 spec, Novotná, **3.** Podhoří, Sept 1988, 12 spec, Oct 1989, 13 spec, Fuchs, **5.** Zoopark, March 1976, 1 spec, Nov 1976, 1 spec, March 1977, 1 spec, May 1980, 1 spec, June 1980, 4 spec, Řeháková, March 1982, 2 spec, April 1982, 3 spec, Vohralík, June 1982, 2 spec, Aug 1982, 3 spec, Dámcová, Vohralík, Oct 1982, 14 spec, Fuchs, Dámcová, Oct 1982, 4 spec, Frynta, July 1983, 3 spec, Vohralík, Oct 1983, 14 spec, Oct 1984, 1 spec, Nov 1984, 4 spec, Dec 1985, 1 spec, Frynta, Nov 1987, 4 spec, Frynta, Žižková, **11.** Dáblický les, May 1980, 2 spec, Hodková, **12.** Chabry, Oct 1989, 1 spec, Frynta, Zelinková, **13.** Dáblický hrbítov, March 1985, 4 spec, Vohralík, Stopka, April 1988, 5 spec, Vohralík, Novotná, July 1988, 3 spec, May 1989, 6 spec, August 1989, 2 spec, Vohralík, Apr 1990, 2 spec, Vohralík, Cibulková, **15.** Satahická bažantnice and Vinořský park, Dec 1987, 31 spec, Jan 1988, 28 spec, Feb 1988, 32 spec, (Čiháková 1989), Feb 1988, 1 spec, (Šmrček 1988), June 1988, 255 spec, (Čiháková 1989), June 1988, 5 spec, July 1988, 15 spec, (Šmrček 1988), Aug 1988, 119 spec, Sept 1988, 36 spec, Oct 1988, 132 spec, (Čiháková 1989), May 1989, 3 spec, Nov 1989, 2 spec, Nov 1990, 5 spec, Čiháková 1989, **16.** Klánovice Vidrholec forest, June 1988, 34 spec, July 1988, 28 spec, (Švecová 1988), June 1989, 55 spec, (Švecová 1989), May 1990, 4 spec, **17.** Klánovice Blatov forest, Nov 1987, 1 spec, Dec 1987, 2 spec, Aug 1988, 3 spec, Nov 1988, 1 spec, (Řezníček 1988), **18.** Xaverovský háj, 1987, 51 spec, (Šimek, Malina 1987, Šimek 1988b), July 1988, 6 spec, (Šimek 1988b), **19.** CHU V Pískovně, 1987, 47 spec, (Šimek 1987, 1988a), July 1988, 15 spec, (Šimek 1988), **24.** Královice, Oct 1984, 21 spec, (Anděra 1987a), **25.** ČHPV Mýto Nedvězí, 1987-88, 57 spec, (Anděra 1989), **26.** Uhlíněves - Obora, 1987, (Hymová 1987), Nov 1990, 24 spec, Musil, **28.** Kolovraty, Nov 1989, 21 spec, July 1990, 14 spec, Sept 1990, 7 spec, Nov 1990, 31 spec, Škrle, **30.** CHÚ Pátkovická stráž, 1987-88, 18 spec, P Hanák, **31.** Petrovice along Botič stream, above the dam, April-Nov 1979, 14 spec, (Anděra 1987b), Petrovice vicinity of Fantův mlýn, March 1980, 4 spec, Feb-March 1981, 1 spec, Hodková, **32.** Milčovský les, March 1985, 7 spec, April 1985, 3 spec, May 1985, 1 spec, (Zemanová 1986), Oct 1985, 2 spec, Frynta, May 1989, 5 spec, Samková, 1986-87, 22 spec, (Anděra 1987), May 1990, 6 spec, **33.** Újezd along Botič stream, Nov 1987, 3 spec, Frynta, Zelinková, **34.** Pruhořice - along Botič stream, Oct 1979, 5 spec, Hodková, Nov 1989, 8 spec, Sádlo, **35.** Pruhořice park, April 1983, 8 spec, May 1983, 21 spec, June 1983, 21 spec, Aug 1983, 15 spec, Sept 1983, 12 spec, Oct 1983, 21 spec, (Korbová 1985), Nov 1983, 6 spec, Frynta, March 1984, 11 spec, April 1984, 17 spec, May 1984, 9 spec, June 1984, 6 spec, July 1984, 16 spec, Sept 1984, 17 spec, Oct 1984, 5 spec, (Korbová 1985), **36.** Hmčářské louky, Oct 1987, 16 spec, (Horáček et al 1987), **38.** Kunratický les, May 1980, 1 spec, Hodková, May 1981, 4 spec, June 1981, 14 spec, Aug 1981, 11 spec, Oct 1981, 8 spec, Hora, Oct 1984, 9 spec, Průchova, Vohralík, Nov 1984, 6 spec, Kulich, Průchová, May 1985, 23 spec, Horová, Kadlecová, Vohralík, Sept 1985, 2 spec, Kadlecová, Vohralík, Oct 1985, 19 spec, Vohralík, Zemanová, May 1986, 1 spec, Horová, Sept 1986, 2 spec, Vohralík, Oct 1986, 10 spec, Weidinger, Oct 1987, 1 spec, (Horáček et al 1987), Oct 1987, 8 spec, Weidinger, Oct 1987, 4 spec, Vohralík, Geussová, May 1989, 6 spec, Voříšek, Oct 1989, 2 spec, Vohralík, **40.** Hostivař along Botič stream, May 1989, 4 spec, May 1990, 3 spec, Zelinková, **63.** V lučinách street, Nov 1990, 17 spec, Frynta, **64.** Modřany, March 1980, 2 spec, (Anděra 1987a), **66.** Modřanská rokli, Aug-Sept 1988, 33 spec, Horáček, Hošek, Nov 1990, 49 spec, Frynta, **67.** ČHPV Šance, Aug 1987, 3 spec, June 1988, 3 spec, July 1988, 2 spec, (Koblicová 1989), **70.** Chuchelský háj, Sept 1988, 5 spec, Hymová, Dec 1988, 2 spec, Jan 1989, 5 spec, Feb 1989, 1 spec, (Fridrich et al 1989), **72.** Klukovice and Holyně - along Dalejský stream, Dec 1980, 2 spec, Sádlo, Švecová, Aug 1989, 17 spec, Sept 1989, 15 spec, Benda, Aug 1990, 1 spec, SPR Prokopské údolí - along Dalejský stream, 1983-86, 35 spec, (Anděra 1986), **73.** SPR Prokopské údolí (Butovická cesta - Bašta Děvín), 1983-86, 4 spec, (Anděra 1986), **82.** CHÚ U Hájů, Dec 1988, 1 spec, (Fridrich et al 1989), **83.** Ruzyně - Hostivice, Dec 1987, 11 spec, Stopka, April 1989, 2 spec, Stopka, Frynta, Zelinková, Nov 1990, 5 spec, Stopka, Vykopalová, Černý, **84.** Hvězda, (Hanzal 1982),

Aug 1982, 1 spec, Sept 1987, 1 spec, Frynta, **98.** Baba, Nov 1989, 3 spec, Kodym, **99.** Arabská, July 1988, 1 spec, Jarešová, **100.** Červený vrch, May 1989, 2 spec, Jarešová, **101.** Tichá Šárka, May 1989, 2 spec, Kozlová, Jenerálka, 5 spec, June 1990, Jarešová, **102.** Divoká Šárka, April 1980, 1 spec, Hodková, Aug 1981, 7 spec, Hora, Frynta, Sept 1981, 14 spec, Hora, Oct 1981, 1 spec, Bramš, Sept 1982, 13 spec, Frynta, Oct 1982, 1 spec, Sept 1983, 5 spec, Frynta, Sept 1988, 5 spec, Frynta, Kodejšová, May-July 1988, 16 spec, Jarešová, May-June 1989, 8 spec, Stopka, **105.** Tiché údolí, Sept 1982, 1 spec, Frynta, Nov 1986, 7 spec, Stopka, May 1990, 9 spec, Bahníková, Nov 1990, 26 spec, Kozlová

### *Microtus arvalis* (Pallas, 1779)

**2.** Čimice, Nov 1989, 17 spec, Stopka, **3.** Podhoří, Sept 1988, 2 spec, Fuchs, **5.** Zoopark, April 1976, 1 spec, July 1976, 1 spec, May 1978, 1 spec, June 1978, 1 spec, Reháková, Aug 1982, 1 spec, Dánková, Oct 1982, 1 spec, Fuchs, July 1983, 1 spec, Štěpánek, Oct 1983, 3 spec, Frynta, Dec 1987, 1 spec, Frynta, Žizková, 6 Troja, May 1989, 13 spec, Marks, **9.** Davidkova street 74, 1969-89, 1 spec, Vohralík, **12.** Chabry, Oct 1989, 14 spec, Frynta, Zelinková, **13.** Dáblický hřbitov, Aug 1989, 1 spec, Vohralík, **14.** Prosek, Oct 1982, 1 spec, Frynta, **15.** Satalická bažantnice and Vinořský park, Feb 1988, 1 spec, (Čiháková 1989), June 1988, 4 spec, July 1988, 5 spec, (Šmrček 1988), Aug 1988, 5 spec, Sept 1988, 3 spec, Oct 1988, 25 spec, May 1989, 4 spec, Nov 1989, 16 spec, (Čiháková 1989), **17.** Klánovice - Biatov forest, Aug 1988, 3 spec, Rezníček, **18.** Xaverovský háj, Sept-Nov 1987, 17 spec, (Šimek, Malina 1987, Šimek 1988b), July 1988, 7 spec, (Šimek 1988b), **19.** CHÚ V Práskově, 1987, 16 spec, (Šimek 1987, 1988a), July 1988, 27 spec, (Šimek 1988a), **24.** Královice, Oct 1984, 3 spec, (Anděra 1987a), **25.** ČHPV Mýto Nedvězí, 1987-88, 11 spec, (Anděra 1989), **26.** Uhlíněves - Obora forest, 1987, (Hymová 1987), **28.** Kolovraty - Prknovka forest, Nov 1990, 4 spec, Skrle, **30.** CHU Pitkovická stráň, 1987-88, 1 spec, P Hanák, **31.** Petrovice - along Botič stream above the dam, April-Nov 1979, 1 spec, (Anděra 1987b), Petrovice - vicinity of Fantův mlýn, March 1980, 2 spec, Feb - March 1981, 8 spec, Hodková, **32.** Milíčovský les, March 1985, 5 spec, April 1985, 4 spec, (Zemanová 1986), May 1989, 1 spec, Samková, 1986-87, 6 spec, (Anděrová 1987), **35.** Průhonice park, April 1983, 4 spec, Sept 1983, 2 spec, April 1984, 1 spec, May 1984, 1 spec, July 1984, 1 spec, (Korbová 1985), **36.** Hrnčířské louky, April 1987, 5 spec, Oct 1987, 60 spec, (Horáček et al 1987), **38.** Kunratický les, Aug 1981, 4 spec, Oct 1981, 1 spec, Hora, Sept 1985, 11 spec, Vohralík, Kadlecová, Zemanová, May 1986, 1 spec, Koblicová, Oct 1987, 1 spec, (Horáček et al 1987), **40.** Hostivař - along Botič stream, Sept 1982, 3 spec, Frynta, Hostivař - SPR Meandry Botiče, Aug - Oct 1985, 3 spec, (Anděra 1987b), **42.** Zahradní Město, Sept 1982, 4 spec, Frynta, **47.** Strašnice - Žalovské hřbitovy, May 1989, 5 spec, June 1990, Kopský, **49.** Vítkov, Sept 1980, 2 spec, Sept 1982, 1 spec, Frynta, **61.** Braník, Nov 1970, 1 spec, Zbytovský, May 1986, 2 spec, July 1986, 17 spec, Aug 1986, 1 spec, Sept 1986, 1 spec, Oct 1986, 5 spec, Nov 1986, 3 spec, Aug 1988, 7 spec, (Koblicová 1989), **66.** Modřanská rokle, Aug - Sept 1988, 2 spec, (Horáček, Hošek 1988), **68.** Zbraslav, 1989, Hrdý (in verb), **70.** Chuchelský háj, Oct 1988, 2 spec, Nov 1988, 5 spec, (Hymová 1988), Dec 1988, 1 spec, (Fridrich et al 1989), **72.** Klukovice and Holyně - along Dalejský stream, Nov 1989, 2 spec, May Aug 1989, 1 spec, Benda, SPR Prokopské údolí - along Dalejský stream, 1983-86, 1 spec, (Anděra 1986), **73.** SPR Prokopské údolí (Butovická cesta - Bašta - Děvín), 1983-86, 38 spec, (Anděra 1986), **74.** Prokopské údolí (Bašta - Dlouhý hřbet), 1983-86, 25 spec, (Anděra 1986), **75.** Prokopské údolí (above old cemetery in Radlice), July 1986, 3 spec, (Anděra 1986), **76.** Pod Kesznerkou street, June 1988, 1 spec, Sept 1988, 2 spec, (Geussová 1989), **77.** Výmolova street, July 1988, 5 spec, Aug 1988, 1 spec, (Geussová 1989), **78.** Na Farkáně, Sept 1988, 1 spec, V Hanák, Malvazinky, May 1989, 1 spec, Exnerová, **82.** CHÚ U Hájů, Jan 1989, 9 spec, (Fridrich et al 1989), **83.** Ruzyně - Hostivice, Dec 1987, 2 spec, Stopka, **84.** Hvězda, Aug 1982, 6 spec, July 1983, 3 spec, Frynta, **85.** Rybníčná street 17, Feb 1985, 1 spec, Pokorný, **86.** Markéta, March 1982, 16 spec, Aug 1982, 36 spec, Frynta, **88.** Petřín, Oct 1980, 3 spec, Frynta, **93.** Jasliská street, Feb 1980, 2 spec, Hodková, **96.** Stromovka, Nov 1980, 7 spec, Feb 1982, 1 spec, Nov 1983, 1 spec, April 1984, 1 spec, Frynta, **97.** Císařský ostrov, Feb 1980, 1 spec, Hodková, March 1982, 6 spec, Frynta, **99.** Arabská, July 1988, 15 spec, 1989, 42 spec, Jarešová, **102.** Divoká Šárka, Aug 1981, 15 spec, Hora, Frynta, Sept 1981, 8 spec, Hora, Sept 1988, 1 spec, Frynta, Kodejšová, Holá, Sept 1989, 1 spec, Frynta, Vykopalová, May-July 1988, 15 spec, Jarešová, June 1989, 1 spec, Stopka, **103.** Přední Kopanina, May 1989, 1 spec, Bílý

*Pitymys subterraneus* (de Selys-Longchamps, 1839)

25. CHPV Mýto-Nedvězí, 1987-88, 1 spec., (Anděra 1989); 32. Milčovský les, May 1989, 1 spec., Samková; 35. Průhonice park, June 1983, 1 spec., July 1984, 1 spec., Sept. 1984, 3 spec., (Korbová 1985); 38. Kunratický les, June 1962, 5 spec., V. Hanák; May 1980, 2 spec., Hodková; Aug. 1981, 3 spec., Hora; Sept. 1985, 1 spec., Vohralík; Oct. 1987, 5 spec., (Horáček et al. 1987); 40. Hostivař - along Botič stream, Sept. 1982, 2 spec., Frynta; 63. V lučinách street, Sept. 1982, 1 spec., Frynta; 66. Modřanská rokle, Aug.-Sept. 1988, 6 spec., (Horáček, Hošek 1988); 67. CHPV Šance, Aug. 1987, 1 spec., (Koblicová 1989).

*Apodemus sylvaticus* (Linnaeus, 1758)

1. Dražanské údolí, May 1989, 1 spec., Novotná; 2. Bohnice, June 1989, 1 spec., Novotná; 3. Podhoří, Sept. 1988, 23 spec., Oct. 1989, 8 spec., Fuchs; 5. Zoopark, March 1976, 3 spec., April 1976, 5 spec., May 1976, 9 spec., July 1976, 2 spec., Sept. 1976, 1 spec., Nov. 1976, 1 spec., March 1977, 2 spec., March 1978, 3 spec., April 1978, 6 spec., May 1978, 4 spec., May 1980 1 spec., June 1980, 3 spec., Řeháková; March 1982, 5 spec., April 1982, 22 spec., Vohralík, Dámcová, Sigmund; May 1982, 2 spec., Dámcová, Matoušová; June 1982, 15 spec., Vohralík, Dámcová, Cízová, Sigmund; Aug. 1982, 18 spec., Dámcová, Vohralík; Oct. 1982, 35 spec., Fuchs, Dámcová; Oct. 1982, 17 spec., April 1983, 3 spec., Frynta; July 1983, 24 spec., Vohralík, Štěpánek; Oct. 1983, 44 spec., Frynta; Feb. 1984, 5 spec., Dámcová; March 1984, 4 spec., Oct. 1984, 21 spec., Nov. 1984, 28 spec., Dec. 1985, 24 spec., Frynta; Oct. 1987, 35 spec., Frynta, Zelinková; Nov. 1987, 11 spec., Dec. 1987, 4 spec., Frynta,

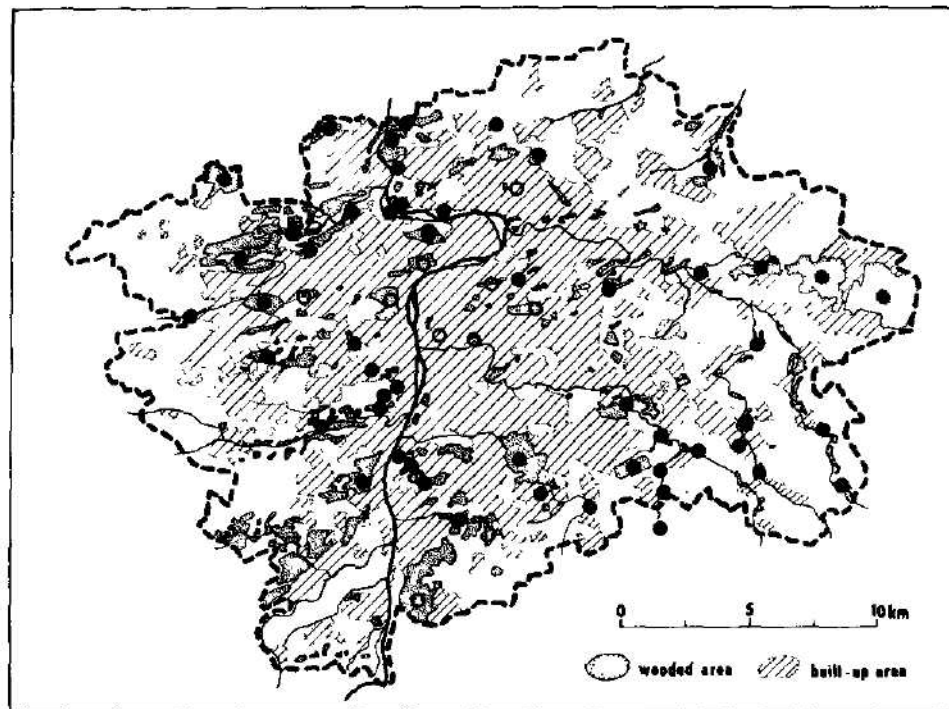


Fig. 2. Distribution of *Sorex araneus* in Prague. Explanations: Dark rings - localities in which the species was recorded. Open rings - localities from which sufficient sample (sample containing of more than 75 small mammal specimens or that obtained after trapping effort exceeding 1000 trap nights) is available, but the species was not recorded.

Žižková; 6. U Vltavy street, Jan. 1984, 2 spec., Dámecová; Troja, May 1989, 1 spec., Marks; 8. Na Stráži, June 1988, 1 spec., Vohralík; 9. Davidkova 74, 1969-89, 108 spec., Vohralík; 11. Dáblický les, May 1980, 2 spec., Hodková; 12. Chabry, Oct. 1989, 59 spec., Frynta, Zelinková; 13. Dáblický hřbitov, March 1985, 8 spec., Vohralík, Stopka; April 1988, 8 spec., Vohralík, Novotná; July 1988, 22 spec., May 1989, 15 spec., Aug. 1989, 22 spec., Vohralík; Apr. 1990, Vohralík, Cibulková; May 1990, 15 spec., Vohralík, Kolářová; 15. Satalická bažantnice and Vnořský park, Dec. 1987, 13 spec., Jan. 1988, 2 spec., Feb. 1988, 4 spec., June 1988, 14 spec., (Čiháková 1989); June 1988, 6 spec., July 1988, 12 spec., (Šmrček 1988); Aug. 1988, 30 spec., Sept. 1988, 18 spec., Oct. 1988, 28 spec., (Čiháková 1989); May 1989, 6 spec., Nov. 1989, 17 spec., May 1990, 3 spec., Nov. 1990, 17 spec., Čiháková; April 1990, 3 spec., Frynta, Čiháková, Zelenková; 16. Klánovice - Vidrholc forest, June 1988, 6 spec., July 1988, 8 spec., (Švecová 1988); June 1989, 12 spec., (Švecová 1989); 17. Klánovice - Blatov forest, Nov. 1987, 1 spec., Dec. 1987, 15 spec., Nov. 1988, 15 spec., (Řezníček 1988); 18. Xaverovský háj, 1987, 50 spec., (Šimek, Malina 1987, Šimek 1988b); July 1988, 18 spec., (Šimek 1988b); 19. CHÚ V Pískovně, 1987, 6 spec., (Šimek 1987, 1988a); July 1988, 6 spec., (Šimek 1988a); 20. Jahodnice, Aug. 1974, 2 spec., Burda; 21. Malešice, March 1982, 3 spec., Chvojka; 22. U kombinátu street, Oct. 1981, 4 spec., Frynta; 23. Dubeč, Nov. 1984, 3 spec., (Anděra 1987a); 24. Královice, Oct. 1984, 29 spec., (Anděra 1987a); 25. CHPV Mýto - Nedvězí, 1987-88, 34 spec., (Anděra 1989); 26. Uhřetěves - Obora, 1987, (Hyniová 1987); Nov. 1990, 31 spec., Musil; 27. Uhřetěves, May 1966, 4 spec., Šmaha; Jun. 1977, 2 spec., Feb. 1977, 2 spec., Jan. 1981, 6 spec., Červený; 28. Kolovraty, Nov. 1989, 12 spec., Nov. 1990, 16 spec., Škrle; 30. CHÚ Pitkovická stráž, 1987-88, 24 spec., P. Hanák; 31. Petrovice - along Botič stream, above the dam, April-Nov. 1979, 42 spec., (Anděra 1987b); Petrovice - vicinity of Pantuv mlýn, March 1980, 12 spec., Feb.-March 1981, 6 spec., Hodková; 32. Milčevský les, March 1985, 6 spec., April 1985, 1 spec., (Zemanová 1986); 1986-87, 28 spec., (Anděrová 1987); May 1989, 10 spec., Samková; May 1990, 1 spec., Dlouhá; 33. Újezd - along Botič stream, Nov. 1979, 16 spec., Hodková; Nov. 1987, 3 spec., Frynta, Zelinková; 34. Pruhonice, Oct. 1979, 40 spec., Hodková; Nov. 1989, 18 spec., Sádlo; 35. Pruhonice park,

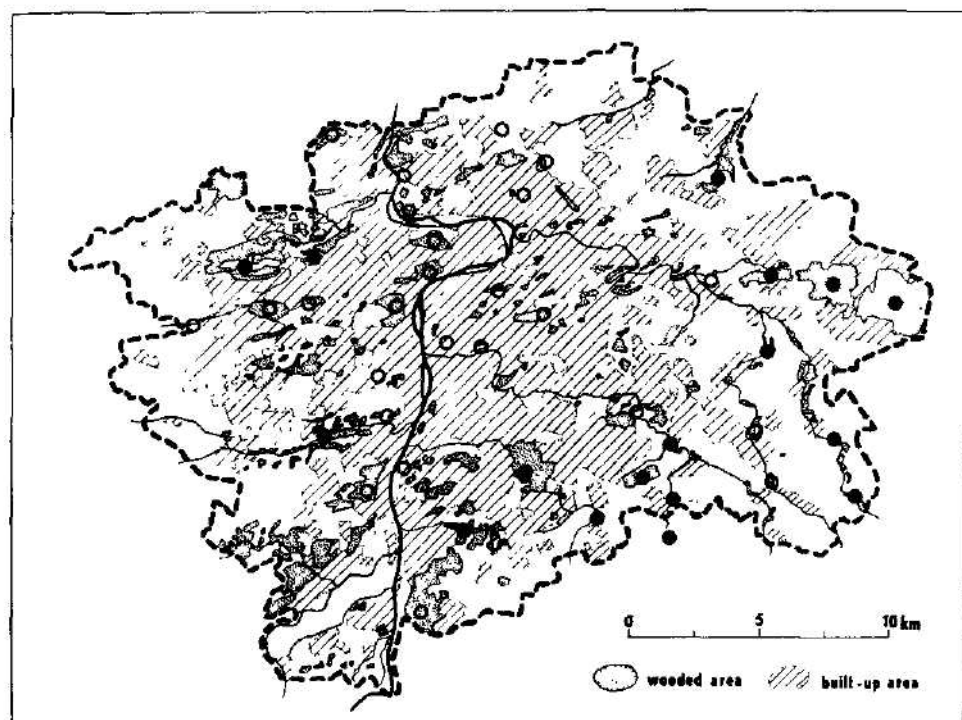


Fig. 3. Distribution of *Sorex minutus* in Prague. For explanation see Fig. 2.

April 1983, 3 spec., May 1983, 10 spec., June 1983, 2 spec., Aug. 1983, 4 spec., Sept. 1983, 5 spec., Aug. 1984, 2 spec., Sept. 1984, 5 spec., (Korbová 1989); **36.** Hrněšfské louky, May 1987, 9 spec., Oct. 1987, 22 spec., (Horáček et al. 1987); **38.** Kunratický les, May 1980, 1 spec., Hodková; March 1981, 4 spec., April 1981, 15 spec., May 1981, 4 spec., June 1981, 5 spec., Aug. 1981, 28 spec., Oct. 1981, 21 spec., Hora; Oct. 1984, 5 spec., Kulich, Vohralík; Nov. 1984, 14 spec., Kulich, Průchová, May 1985, 8 spec., Vohralík, Horová, Kadlecová; Sept. 1985, 35 spec., Vohralík, Kadlecová, Zemanová; Oct. 1985, 21 spec., Vohralík, Zemanová; Sept. 1986, 11 spec., Vohralík, Horová, Šálek, Weidinger; Oct. 1986, 5 spec., Šálek, Weidinger; Dec. 1986, 2 spec., Šálek, Oct. 1987, 16 spec., (Horáček et al. 1987); Sept. 1987, 29 spec., Vohralík, Šálek, Černý; Oct. 1987, 9 spec., Weidinger; Oct. 1987, 24 spec., Geussová, Vohralík; May 1989, 14 spec., Voříšek; Oct. 1989, 5 spec., Vohralík; July 1990, 24 spec., Koroljeva, Škrle, Vohralík; **40.** Hostivař - along Botič stream, Sept. 1982, 26 spec., Frynta; Hostivař - SPR Meandry Botiče, Aug.-Oct. 1985, 75 spec., (Anděra 1987b); May 1989, 15 spec., May 1990, 6 spec., Zelinková; **43.** Bohdalec, May 1989, 3 spec., Volf; Nov. 1989, 19 spec., Maňásek; **44.** Hlavíčkovy sady, June 1980, 15 spec., Dec. 1980, 3 spec., Frynta; Sept. 1985, 4 spec., Vohralík, Zemanová; May 1989, 12 spec., Nov. 1989, 2 spec., Svobodová; **47.** Strašnice - Židovské hřbitovy, Aug. 1982, 13 spec., Frynta; May 1989, 21 spec., Nov. 1989, 16 spec., May 1990, 42 spec., Kopský; Nov. 1990, 48 spec., Exnerová, **48.** Ohrada, Nov. 1989, 4 spec., Exnerová; **49.** Vítkov, Sept. 1980, 24 spec., Sept. 1982, 6 spec., Frynta; **54.** Apolnářská street, April 1982, 3 spec., Jan 1984, 1 spec., Dámecová; Vinická street 7, June 1987, 1 spec., Mácha; May 1989, 1 spec., Nov. 1989, 4 spec., Brandlová; **60.** Velký háj, Dec. 1985, 9 spec., Frynta, Skála, **61.** Braník, April 1986, 1 spec., May 1986, 16 spec., July 1986, 40 spec., Aug. 1986, 16 spec., Sept. 1986, 20 spec., Oct. 1986, 10 spec., Nov. 1986, 11 spec., Aug. 1987, 45 spec., Sept. 1987, 45 spec., April 1988, 2 spec., Aug. 1988, 62 spec., Sept. 1988, 45 spec., Oct. 1988, 26 spec., (Koblicová 1989); **63.** V lučinách street, Sept. 1982, 2 spec., Nov. 1990, 29 spec., Frynta, **64.** Nad vinicí street, March 1980, 15 spec., Hodková, Modřany, March 1980, 2 spec., (Anděra 1987a); **66.** Modřanská rokle, Aug.-Sept. 1988, 26 spec., (Horáček, Hošek 1988); May 1990, 2 spec., Zelinková, Nov. 1990, 20 spec., Zelinko-

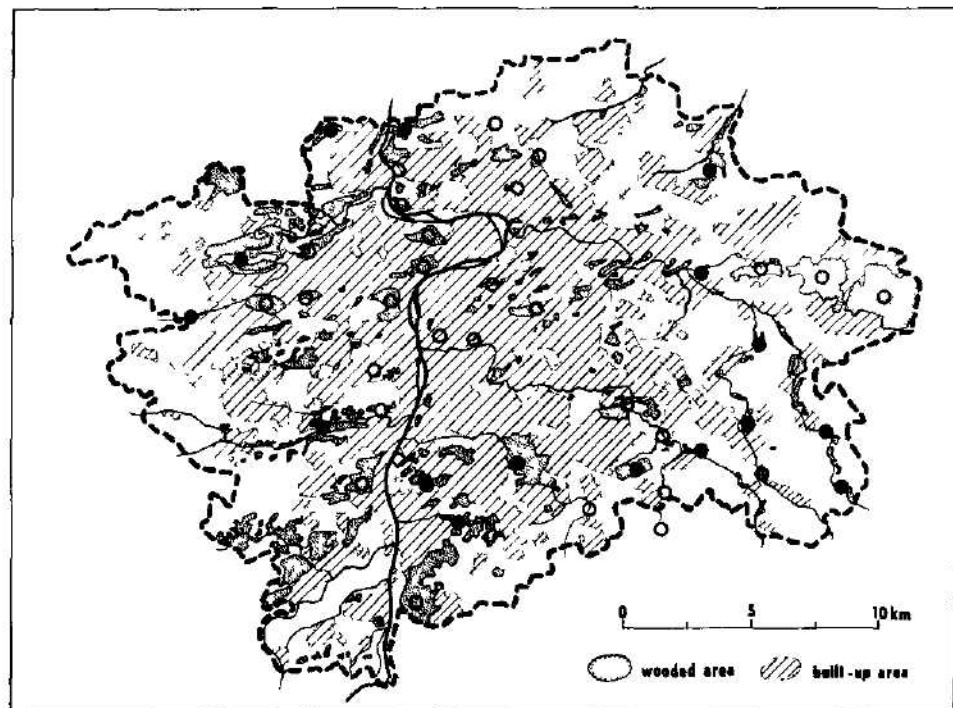


Fig. 4. Distribution of *Neomys fodiens* in Prague. For explanation see Fig. 2.



vá; 67. CihP V Šance, Aug. 1987, 8 spec., Oct. 1987, 3 spec., June 1988, 2 spec., (Koblicová 1989); 68. Zbraslav, 1989, Hrdý (in verb.); 70. Chuchelský háj, Sept. 1988, 3 spec., Oct. 1988, 6 spec., Nov. 1988, 1 spec., Dec. 1981, 10 spec., (Hyniová 1988); Dec. 1988, 12 spec., Jan. 1989, 4 spec., (Fridrich et al. 1989); 72. SPR Prokopské údolí - along Dalejský stream, 1983-86, 29 spec., (Anděra 1986); Klukovice and Holyně - along Dalejský stream, Dec. 1980, 6 spec., Sádlo, Švecová; June 1989, 1 spec., Stopka; May-Aug. 1989, 22 spec., Nov. 1989, 24 spec., Benda; 73. SPR Prokopské údolí (Butovická cesta - Bašta - Děvín), 1983-86, 48 spec., (Anděra 1986); 74. SPR Prokopské údolí (Bašta-Dlouhý hrbet), 1983-86, 21 spec., (Anděra 1986); 75. Prokopské údolí - above old cemetery in Radlice, July 1986, 8 spec., (Anděra 1986); 76. Pod Kesnerkou street, Jan. 1975, 2 spec., March 1982, 2 spec., Sigmund; June 1988, 4 spec., Sept. 1988, 1 spec., Nov. 1988, 1 spec., (Geussová 1989); 77. Výmolova street, July 1988, 9 spec., Aug. 1988, 2 spec., (Geussová 1989); 78. Na I-arkáně, March-Sept. 1988, 52 spec., V. Hanák; May 1989, 4 spec., Exnerová, Nov. 1989, 2 spec., Vykopalová; 79. Santoška, May 1989, 4 spec., Exnerová; 82. CihP U Háju, Dec. 1988, 1 spec., Jan. 1989 16 spec., (Fridrich et al. 1989); 83. Ruzyně - Hostivice, Oct. 1986, 11 spec., Dec. 1987, 10 spec., Stopka; April 1989, 6 spec., Stopka, Frynta, Zelinková; Nov. 1990, 7 spec., Stopka, Vykopalová, Černý; 84. Hvězda, Nov. 1969, 11 spec., Slavíček; Feb. 1971, 3 spec., Vobořil; Nov. 1972, 6 spec., J. Zima; May 1981, 35 spec., Hora; Aug. 1981, 39 spec., Aug. 1982, 72 spec., July 1983, 111 spec., Dec. 1984, 2 spec., Sept. 1987, 104 spec., Frynta; Feb. 1988, 1 spec., Žižková, Šálek; May 1989, 2 spec., Vykopalová; 85. Rybníčná 17, 1985-90, 23 spec., Pokorný; 86. Markéta, March 1982, 4 spec., Frynta; May 1982, 1 spec., Dáncová; Aug. 1982, 9 spec., Frynta; April 1986, 3 spec., Frynta, Vohralík; May 1989, 2 spec., Maňáková, Nov. 1989, 18 spec., Šroller, Voříšek; 87. Radimova street, May 1982, 3 spec., Dáncová; 88. Petřín, May 1980, 7 spec., Hodková; Oct. 1980, 10 spec., Sept. 1981, 11 spec., Frynta; March 1982, 6 spec., Vohralík; Sept. 1982, 35 spec., Jan. 1983, 16 spec., Sept. 1987, 27 spec., Frynta; Oct. 1987, 5 spec., Frynta, Zelinková; Nov. 1989, 4 spec., Ráža; 91. Vojanovy sady, Oct. 1980, 5 spec., Frynta; 92. U Letohrádku knižovny Anny street, Feb. 1984, 2 spec., Křepelová; Chotkovy sady, May 1989, 7 spec., Škrle; Nov. 1989, 4 spec., Storch; May 1990, 2 spec., Bílý; 93. Jaselská street,

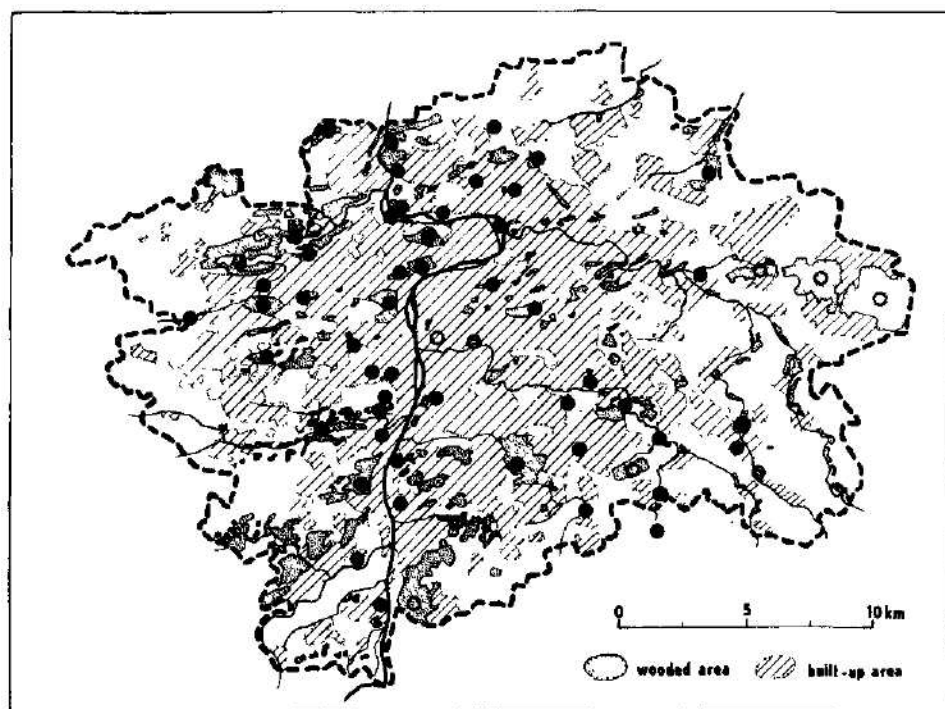


Fig. 5. Distribution of *Crocidura suaveolens* in Prague. For explanation see Fig. 2.

March-April 1980, 4 spec., Hodková; **94.** Letenské sady, June 1980, 6 spec., Frynta; Nov. 1989, 5 spec., Šálek; **95.** Libeňský ostrov, Sept. 1984, 5 spec., Frynta, Kubečka; **96.** Stromovka, June 1980, 85 spec., Aug. 1980, 30 spec., Oct. 1980, 6 spec., Nov. 1980, 39 spec., June 1981, 35 spec., Aug. 1981, 76 spec., Nov. 1981, 23 spec., Feb. 1982, 2 spec., Aug. 1982, 18 spec., July 1983, 43 spec., Nov. 1983, 25 spec., April 1984, 50 spec., June 1985, 28 spec., Oct. 1985, 35 spec., Aug. 1986, 38 spec., May 1989, 8 spec., Nov. 1989, 3 spec., June 1990, 6 spec., Frynta; Nov. 1990, 51 spec., Cibulková; **97.** Císařský ostrov, Feb. 1980, 7 spec., Hodková; March 1982, 8 spec., Frynta; **98.** Na Mláčance street, March 1988, 2 spec., Frynta; Baba, Nov. 1989, 7 spec., Kodym; **99.** Arabská street, July 1988, 14 spec., Jan. 1989, 5 spec., Feb. 1989, 3 spec., March 1989, 3 spec., April 1989, 2 spec., May 1989, 2 spec., June 1989, 3 spec., July 1989, 10 spec., Sept. 1989, 5 spec., Oct. 1989, 2 spec., Dec. 1989, 1 spec., Jarešová; **100.** Červený vrch, May 1989, 1 spec., Jarešová; **101.** Tichá Šárka, May 1989, 1 spec., Kozlová; June 1990, 1 spec., Jarešová; **102.** Divoká Šárka, Aug. 1981, 64 spec., Hora, Frynta; Sept. 1981, 11 spec., Hora; Oct. 1981, 1 spec., Braniš; Sept. 1982, 10 spec., Sept. 1983, 1 spec., Frynta; Sept. 1988, 10 spec., Frynta, Kodejšová; May-June 1988, 17 spec., Jarešová; May-June 1989, 2 spec., Stopka; **103.** Přední Kopanina, May 1989, 3 spec., Bílý; **104.** Suchbát, 1979, 1 spec., Hodková; **105.** Tiché údolí, Sept. 1982, 27 spec., Frynta; Nov. 1986, 4 spec., Stopka; May 1989, 2 spec., Storch; May 1990, 9 spec., Bahňková; Nov. 1990, 23 spec., Kozlová.

*Apodemus flavicollis* (Melchior, 1836)

**3.** Podhoří, Sept. 1988, 3 spec., Fuchs; **13.** Dáblícký hřbitov, March 1985, 1 spec., Stopka; Apr. 1988, 3 spec., Vohralík, Novotná; July 1988, 4 spec., Vohralík, Apr. 1990, 3 spec., Vohralík, Cibulková; **15.** Satalická bažantnice and Vínofský park, Feb. 1988, 2 spec., June 1988, 3 spec., July 1988, 6 spec., (Srnček 1988), Dec. 1987, 29 spec., Jan. 1988, 13 spec., Feb. 1988, 26 spec., June 1988, 34 spec., Aug. 1988, 51 spec., Sept. 1988, 13 spec.,

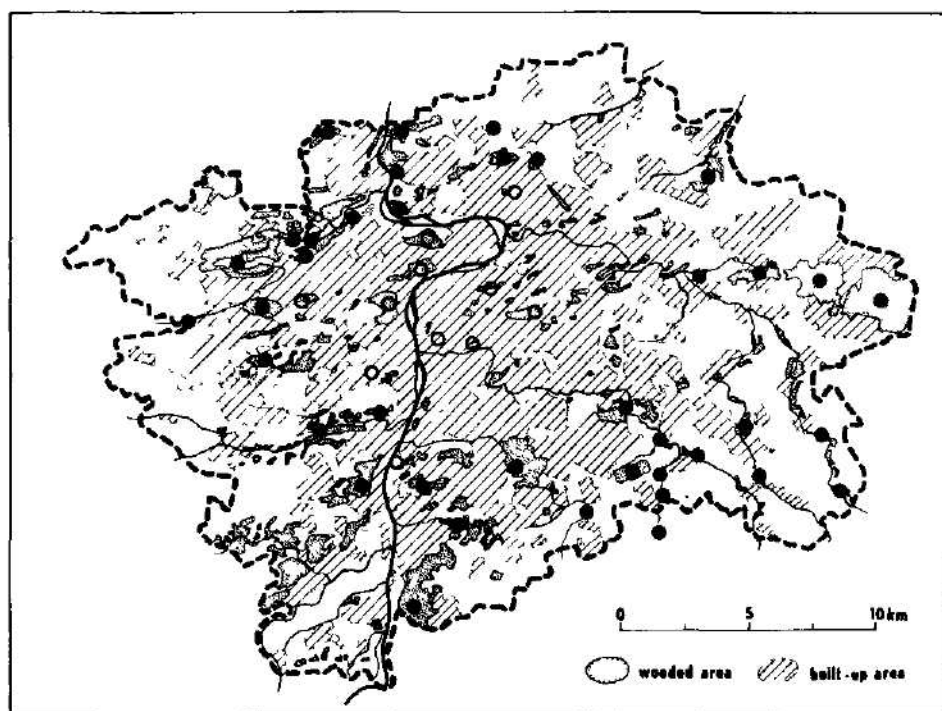


Fig. 6 Distribution of *Clethrionomys glareolus* in Prague. For explanation see Fig. 2.



Oct. 1988, 57 spec., (Čiháková 1989); May 1989, 6 spec., Nov. 1990, 4 spec., Čiháková; 16. Klánovice - Vidřho-  
lec forest, June 1988, 2 spec., July 1988, 5 spec., (Švecová 1988); 18. Xaverovský háj, 1987, 47 spec., (Šimek,  
Malina 1987, Šimek 1988b); July 1988, 17 spec., (Šimek 1988b); 24. Královice, Oct. 1984, 2 spec., (Anděra  
1987a); 25. ČHPV Mýto - Nedvězí, 1987-88, 30 spec., (Anděra 1989); 26. Uhřetěves - Obora forest, 1987,  
(Hyniová 1987); Nov. 1990, 33 spec., Musil; 28. Kolovraty, Nov. 1989, 12 spec., July 1990, 2 spec., Sept. 1990,  
44 spec., Nov. 1990, 16 spec., Škrle; 30. CHÚ Pitkovická stráň, 1987-88, 11 spec., P. Hanák; 31. Petrovice - along  
Botič stream above the dam, April-Nov. 1979, 2 spec., (Anděra 1987b); vicinity of Fantův mlýn, March 1980, 1  
spec., Hodková; 32. Milíčovský les, Oct. 1985, 2 spec., Frynta; May 1990, 7 spec., Dlouhá; 33. Újezd - along  
Botič stream, Nov. 1987, 6 spec., Frynta, Zelinková; 34. Průhonice - along Botič stream, Nov. 1989, 1 spec.,  
Sádlo; 35. Průhonice park, April 1983, 14 spec., May 1983, 18 spec., June 1983, 13 spec., Aug. 1983, 15 spec.,  
Sept. 1983, 24 spec., Oct. 1983, 8 spec., Nov. 1983, (Korbová 1985), 8 spec., Frynta; March 1984, 2 spec., April  
1984, 6 spec., May 1984, 1 spec., June 1984, 2 spec., July 1984, 7 spec., Sept. 1984, 5 spec., Oct. 1984, 4 spec.,  
(Korbová 1985); 38. Kunratický les, June 1981, 1 spec., Hora; Oct. 1987, 2 spec., (Horáček et al. 1987); Oct.  
1987, 1 spec., Vohralík, Geussová; July 1990, 1 spec., Vohralík, Škrle, Koroljeva; 66. Modřanská rokli, Aug-  
Sept. 1988, 5 spec., (Horáček, Hošek 1988); Nov. 1990, 20 spec., Zelinková; 67. ČHPV Šance, Aug. 1987, 39  
spec., Oct. 1987, 19 spec., June 1988, 5 spec., (Koblicová 1989); 70. Chuchelský háj, Dec. 1988, 5 spec., (Fridrich  
et al. 1989); 72. SPR Prokopské údolí - along Dalejský stream, 1983-86, 2 spec., (Anděra 1986); Klukovice -  
Holyně - along Dalejský stream, Sept. 1989, 2 spec., Benda; Aug. 1990, 8 spec., Frynta, Stopka, Zelinková; 100.  
Červený vrch, May 1989, 1 spec., Jarešová; 101. Tichá Šárka, May 1989, 3 spec., Kozlová; 102. Divoká Šárka,  
April 1980, 1 spec., Hodková; Aug. 1981, 3 spec., Hora, Frynta, Sept. 1982, 3 spec., Frynta; May-July 1988, 3  
spec., Jarešová; Sept. 1988, 5 spec., Frynta, Kodejšová, Holá; 105. Tiché údolí, Nov. 1986, 3 spec., Stopka; May  
1990, 1 spec., Bahníková; Nov. 1990, 10 spec., Kozlová.

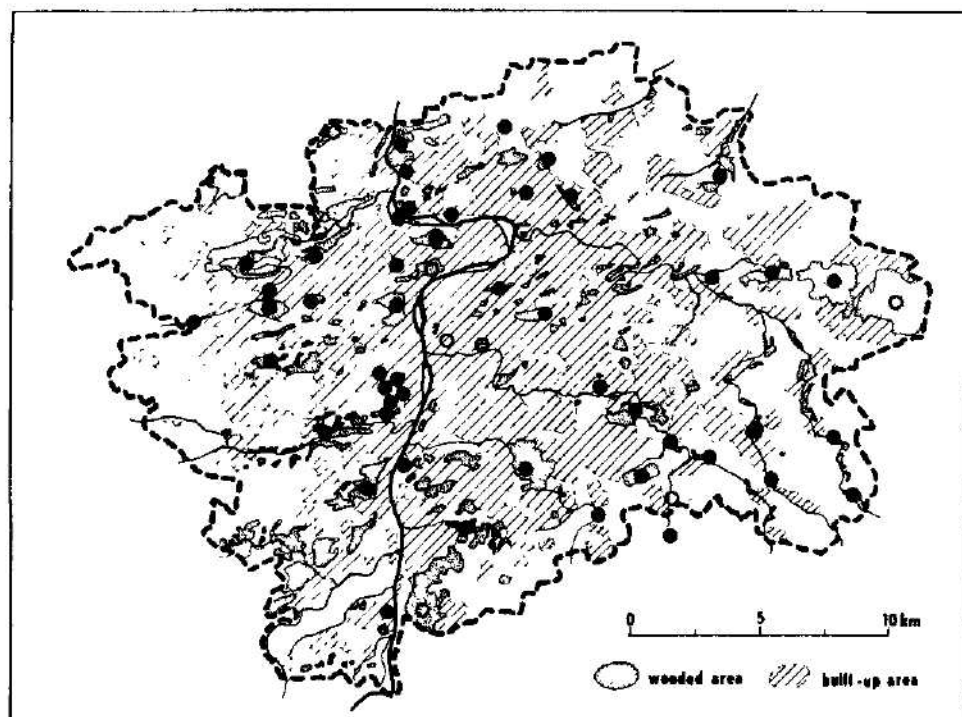


Fig. 7. Distribution of *Microtus arvalis* in Prague. For explanation see Fig. 2.

*Micromys minutus* (Pallas, 1771)

19. V Pískovně, 1987, 1 spec., (Šimek 1987, 1988a); 24. Královice, Oct. 1984, nest record, (Anděra 1989); 36. Šeberák pond, Sept. 1959, nest records (reported as Šeberov pond by Grundová 1962); Brůdek pond, 1987, nest records, (Horáček et al. 1987); 38. Kunratický les, July 1990, 1 spec., Vohralík, Škrle, Koroljeva; 61. Braník, Nov. 1970, 3 spec., Zhytovský; Sept. 1987, 1 spec., Aug. 1988, 1 spec., Sept. 1988, 1 spec., (Koblicová 1989); 77. Výmolova, July 1988, 1 spec., (Geussová 1989); 99. Arabská, Nov. 1989, 1 spec., Jarešová; 103. Přední Kopani-na, May 1989, nest record, Bílý.

*Mus musculus* Linnaeus, 1758

3. Podhoří, Sept. 1988, 1 spec., Fuchs; 5. Zoopark, June 1978, 1 spec., June 1980, 8 spec., Řeháková; May 1982, 2 spec., June 1982, 6 spec., Oct. 1982, 1 spec., Dámcová, Matoušová, Vohralík; 6. Troja, Oct. 1979, 2 spec., Nov. 1979, 11 spec., March 1980, 1 spec., Hodková; 7. V Holešovičkách street, Jan. 1985, 1 spec., Řehák; 9. Davídkova street 74, 1969-89, 43 spec., Vohralík; 12. Chabry, Oct. 1989, 5 spec., Frynta; 15. Satalická bažantnice and Vnořský park, July. 1988, 2 spec., (Smrček 1988); 19. CHÚ V Pískovně, 1987, 1 spec., (Šimek 1987, 1988a); 20. Jahodnice, Aug. 1974, 2 spec., Burda; 22. U kombinátu street, Sept. 1980, 1 spec., Frynta; 27. Uhřetěves, Jan. 1977, 1 spec., Feb. 1977, 1 spec., Sept. 1977, 3 spec., Červený; 29. PDZ Libuš, Dec. 1962, 18. spec., (Trpák 1964); 32. Milčovský les, April 1985, 2 spec., (Zemanová 1986); 37. Kunratic, Jan. 1982, 1 spec., Velčev; 38. Kunratický les, May 1985, 2 spec., Kudleccová; Oct. 1987, 1 spec., Vohralík, Geussová; 40. Hostivař - along Botič stream, May 1989, 1 spec., Zelínková; 44. Havlíčkovy sady, Sept. 1985, 6 spec., Vohralík, Zemanová (Zemanová 1986); 45. Slezská street, Feb. 1984, 3 spec., Frynta; 49. Vítkov, Sept. 1980, 1 spec., Frynta; 50. V kolkovně street

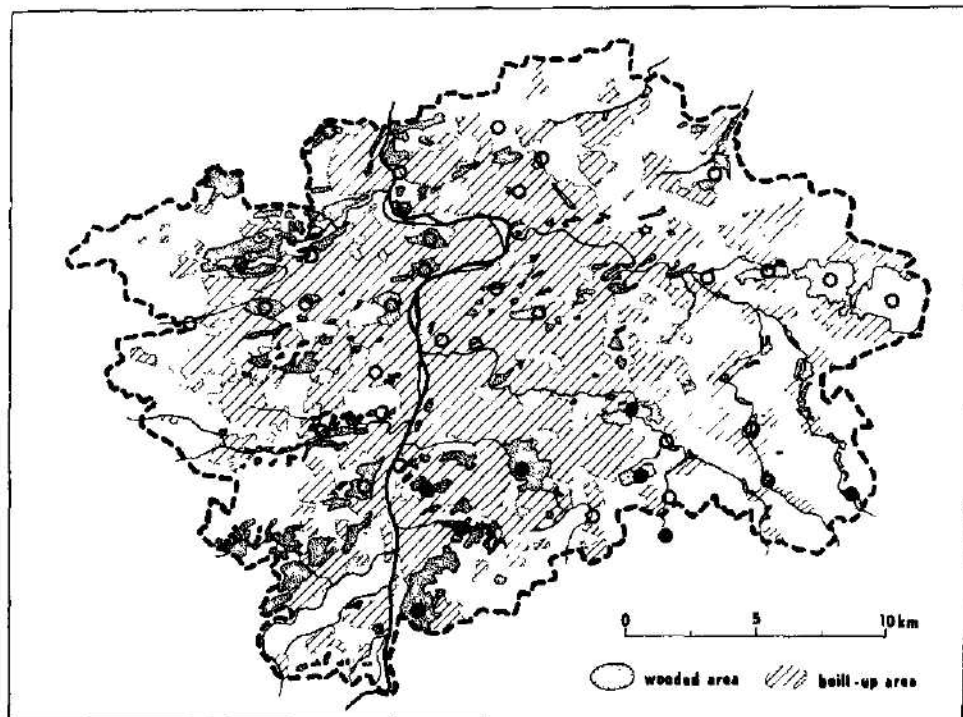


Fig. 8. Distribution of *Pitymys subreanens* in Prague. For explanation see Fig. 2.

8, Oct 1982, 2 spec, Frynta, Týnská street, Sept 1983, 1 spec, Frynta, V kolšovně street 6, Dec 1987, 1 spec, Frynta, 51. Rytířská street, Sept 1984, 1 spec, Frynta, 52. Spálená street 15, Oct 1987, 1 spec, Šálek, Křemencová street, Feb 1990, 1 spec, Kozlová, 53. Karlovo náměstí, 1980, 1 spec, Frynta, 54. Albertov, Dec 1962, 20 spec, April 1963, 59 spec, Albertov - Purkyňův ústav, April 1963, 2 spec, (Trpák 1964), Botanická zahrada, April 1963, 68 spec, Sept Oct 1963, 77 spec, Nov 1963, 48 spec (Trpák 1964), July-Nov 1969, 4 spec, Vohralík, Albertov, Jan 1980, 3 spec, Plesník, Apolinářská street, Aug 1982, 1 spec, Dámecová, Lipová street, March 1984, 1 spec, Frynta, Viničná street 7, 1972-86, 32 spec, Mácha et al, Benátská street 2, 1983-84, 21 spec, Frynta, 55. Výtoň, July 1973, 1 spec, Pásek, 57. Milevská street 1111, Nov 1982, 1 spec, Sept 1983, 1 spec, April 1986, 1 spec, Chvála, 58. Branická street 111, July 1984, 54 spec, Švecová, 59. Na Ryšánce street, Nov 1981, 1 spec, Frynta, 61. Braník, Dec 1970, 1 spec, Zhytovský, May 1986, 1 spec, Sept 1986, 1 spec, Sept 1987, 2 spec, (Koblicová 1989), 65. Pirinská street 3242, Feb 1985, 2 spec, Švátora, 72. SPR Prokopské údolí - along Dalejský stream, 1983-86, 1 spec, (Anděra 1986), 75. Prokopské údolí above old cemetery in Radlice, July 1986, 12 spec, (Anděra 1986), 85. Rybníčná 17, 1985-90, 38 spec, Pokorný, 89. Kampa, Oct 1987, 1 spec, Jarešová, 90. Josefská street, Nov 1980, 1 spec, Oct 1984, 1 spec, Frynta, Mostecká street, April 1982, 8 spec, Frynta, Oct 1989 10 spec, Zelinková, 92. Chotkovy sady, May 1989, 2 spec, Škrle, 93. Jaseňská street, 1979, 2 spec, Hodková, 95. Labeňský ostrov, Sept 1984, 1 spec, Frynta, Kubečka, 98. Na Fišerce street 19, Oct 1981, 10 spec, Kodým, 104. Suchdol, 1979, 2 spec, Hodková

## RESULTS AND DISCUSSION

### Theoretical considerations

According to the theory of island biogeography (Mac Arthur & Wilson 1967, Simberloff 1976) the species richness should be usually lowered in islands. This phenomenon may be caused both by increased extinction rates in islands of small size and by decreased immigration rate caused by isolation. The smaller the island or the greater its distance from the mainland, the lower the number of animal species found there. This concept can be fruitfully applied also to parks isolated by built-up areas (Klausnitzer 1987).

In general, following major factors could limit considerably the small mammal distribution in the city:

1) Low immigration rate. Absence of the species should be expected in localities situated in the centre of the town or in those surrounded by compact built up areas.

2) High extinction rate. Absence of the species should be expected in localities of small size irrespective to their location. Owing to the fact that extinction rate is negatively correlated with population size, the lower the dominance of particular species the higher extinction rate could be expected.

3) Presence or absence of specific habitat required by specialized species. The species is absent in localities with lack of suitable habitat irrespective of their location.

Of course, the time factor, i.e., the duration of present situation and what preceded it, should be taken into account in every particular case.

All the above discussed factors acting simultaneously are responsible for the distribution of urban population. There are apparent differences among individual species as well as towns. For example, pattern and size of an area (VanDruff & Rowse 1986) and habitat type (Dickman 1987) were identified to be the most important factor affecting mammal species richness in Syracuse, U.S.A. and in Oxford, respectively. Shelters were found to be the most important for *A. agrarius* in Warsaw (Babinska-Werka et al. 1979), etc.

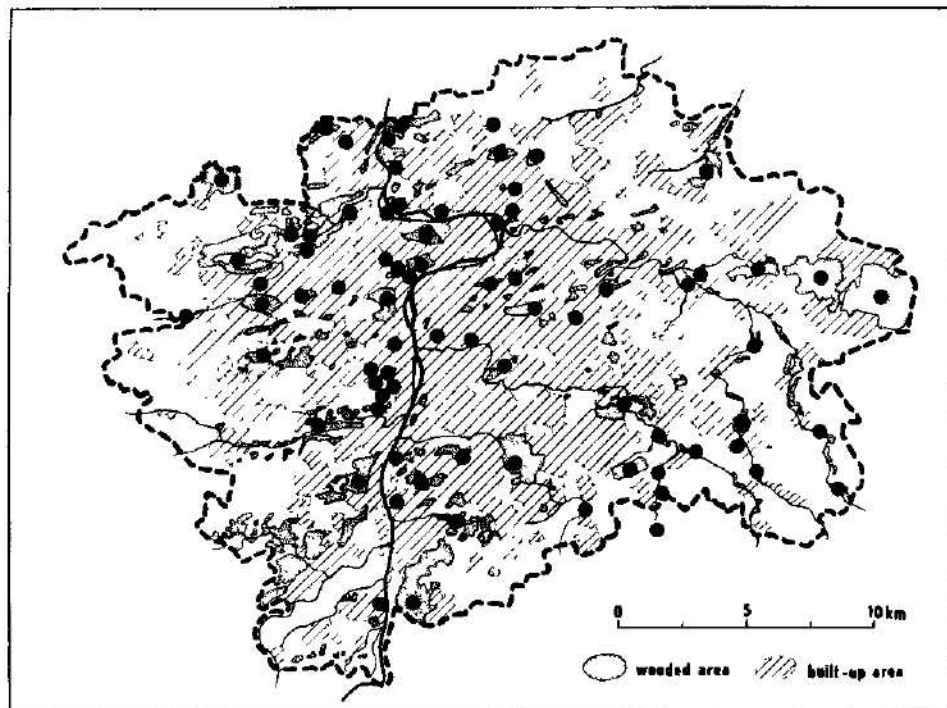


Fig. 9. Distribution of *Apodemus sylvaticus* in Prague. For explanation see Fig. 2.

#### Comments to individual species

##### *Sorex araneus* (Fig. 2)

The Common shrew is present in almost all green areas (52 localities), with the exception of several localities in the centre of Prague (Nos. 49 Vítkov, 47 Strašnice - Židovské hřbitovy, 54 Botanical garden & Albertov, 44 Havlíčkovy sady, 88 Petřín, 94 Letenské sady). Suitable habitats for populations of *S. araneus* are apparently in at least two of these localities (Strašnice - Židovské hřbitov, Petřín). Absence of this species should be attributed to isolation of these localities by built up or other unsuitable areas.

##### *Sorex minutus* (Fig. 3)

The Lesser shrew was found in 17 localities distributed on the outskirts of Prague only. Its occurrence is typical for certain seminatural habitats as woods and alluvial habitats along streams. However, its habitat requirements seem to be more specific than those of the previous species. In view of the fact that *S. minutus* was not found in Satalická Bažantnice and Vinořský park (locality No. 15) during an extensive research by Čiháková, who in 1987-1994 collected there 2549 small mammals (Čiháková 1989, 1994), the record of this species reported from there by Smrček (1988) seems to be problematic.

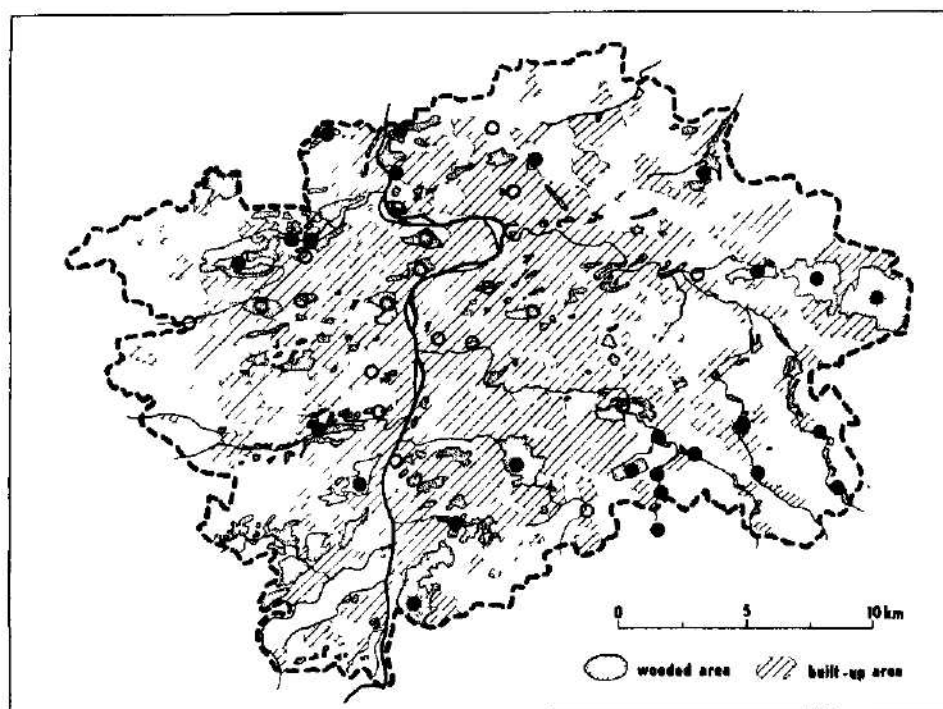


Fig. 10. Distribution of *Apodemus flavicollis* in Prague. For explanation see Fig. 2.

*Neomys fodiens* (Fig. 4)

Records of the Water shrew (16 localities) are confined to peripheral parts of Prague only, where it seems to be fairly common if suitable habitats along streams are available.

*Crocidura suaveolens* (Fig. 5)

The Lesser White-toothed shrew was found in 50 localities including several those in the very centre of Prague. In the center, among localities from which sufficient material was available it was not found only in two (Nos. 44 and 54). On the other hand, absence of this species in samples obtained in larger forest complexes on the periphery of the city is a regular phenomenon, which is in accordance with the general ecological strategy of this species. In Central Europe, *C. suaveolens* prefers warm sunny habitats as shrubby balks and slopes, vineyards, ruderal sites etc., or even buildings (Anděra & Hůrka 1984). In Prague, it seems to be an outdoor dweller, with the exception of cold winter months in which part of its population is concentrated indoor. *C. suaveolens* is the only shrew inhabiting isolated parks and other green areas in the centre of the city. Therefore, its urban populations may probably profit from the absence of their potential competitors.

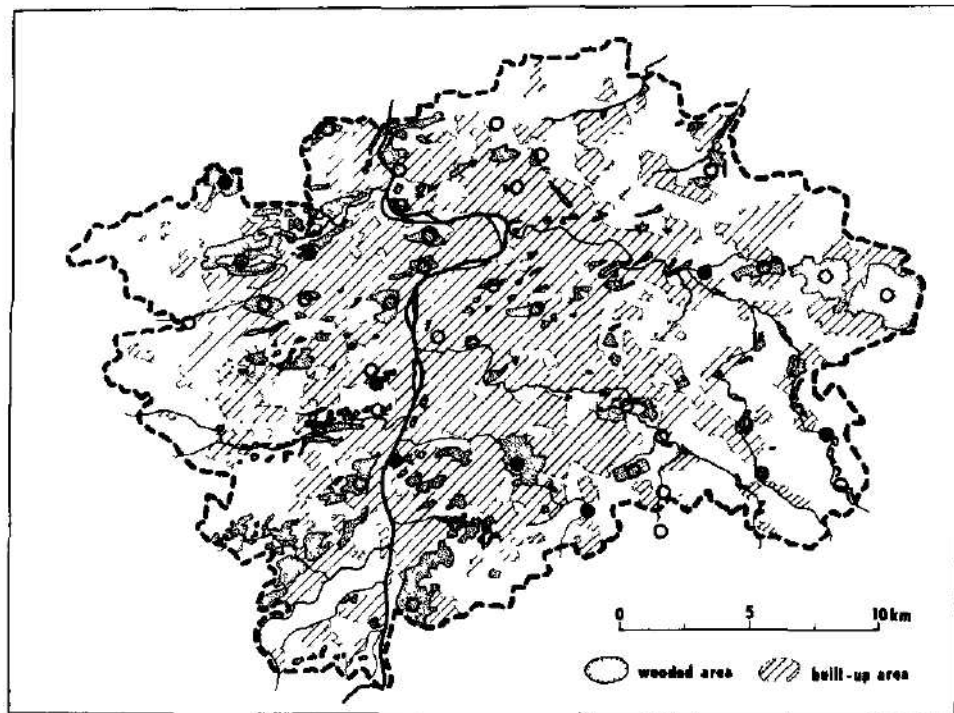


Fig. 11. Distribution of *Micromys minutus* in Prague. For explanation see Fig. 2.

*Clethrionomys glareolus* (Fig. 6)

The Bank vole was recorded in 39 localities situated exclusively on the Prague periphery. It was not found in any of ten localities in the central part of the city, from which sufficient sample were available. In at least four of them (Nos. 47, 49, 88, 96) there are extensive plots of habitats suitable for this species. Owing to the fact that *C. glareolus* is bound to the presence of trees and shrubs, its immigration through built up or open areas without vegetation cover is strongly limited. Moreover, the probability of stochastic extinction in isolated populations of small size is multiplied by periodical fluctuations in population size that are characteristic for this species. Having in mind these facts we can conclude that the present absence of *C. glareolus* in green areas of central Prague is most probably a result of island effects.

*Microtus arvalis* (Fig. 7)

The Common vole is confined to areas covered with grass and therefore it is not directly associated with human settlements. However, it was found in most of the Prague territory (48 localities) including some larger, but isolated, parks in the city centre. In contrast to the above vole, *Clethrionomys glareolus*, it is evident, that in Prague the Common vole possesses ability to penetrate through built up areas.



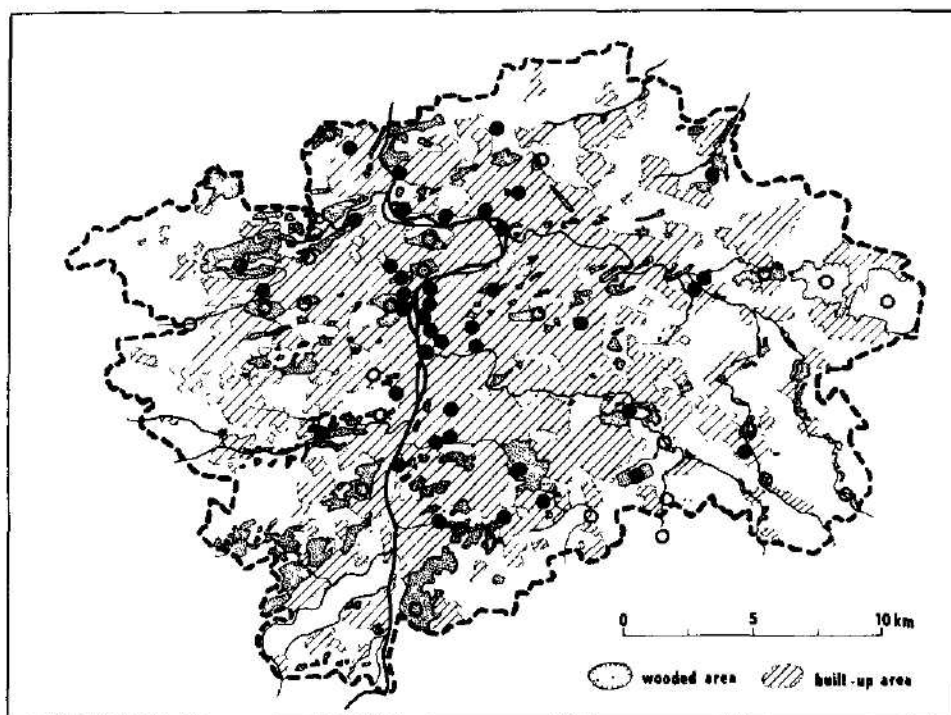


Fig. 12. Distribution of *Mus musculus* in Prague. For explanation see Fig. 2.

*Pitymys subterraneus* (Fig. 8)

The Pine vole occurs in southeast parts of Prague territory only. It was found in eight localities there. However, it has to be remarked here that in spite of the considerable effort, the species have not been found neither in areas adjacent in north and west to Prague (data by V. V.). Therefore, the unusual distribution pattern of *P. subterraneus* in Prague may be ascribed to a local limit of the range of this species.

*Apodemus sylvaticus* (Fig. 9)

The Wood mouse was recorded in 77 localities. It was present in all the samples of sufficient size. Although it is regular winter immigrant into buildings, the Wood mouse is a species not directly associated with human settlements. It has colonized almost all parks and other green areas in the city, becoming a dominant species in localities of this type (Frynta 1982). Urban populations of *A. sylvaticus* may probably gain owing to the absence of their potential competitor, *A. flavicollis*. Population structure and reproduction in *A. sylvaticus* along the urbanization gradient in Prague were described by Frynta (1992, 1993), Frynta & Vohralík (1992, 1994) and Frynta & Žižková (1994).

Successful colonization of urban habitats by this species is common in Europe. This phenomenon is not surprising in context of the fact that *A. sylvaticus* as species showing wide ecological valency is known from various habitats including the extreme ones (Bejček 1983, 1988). It



was reported as a dominant species in parks and other green areas of a number of European cities, e. g.: Manchester (Yalden 1980), Oxford (Dickman 1987, Dickman & Doncaster 1986), České Budějovice (Vlček 1979, Vlček & Kohn 1986) and Brno (Pelikán et al. 1980, 1983). However, this dominance occurs only in absence of *A. agrarius*. In towns within the distribution range of *A. agrarius* (Kratochvíl et al. 1976), this species occupies the niche of the dominant urban dweller and, therefore, the abundance of *A. sylvaticus* is much lower, probably as a result of their mutual competition. This pattern was reported from Berlin (Elvers & Elvers 1984), Leipzig (Klenke 1986), Warsaw (Andrzejewski et al. 1978, Babinska-Werka 1979), Wrocław (Chudoba et al. 1961), Poltava (Gavrilenko 1970), Liberec (Horová 1987), Košice (Mošanský 1985). The only exception of this rule is the city of Alma-Ata, Kazakhstan, where Wood mouse is more abundant than *A. agrarius* (Stogov 1988). However, the taxonomic position of Wood mouse populations from this region, traditionally considered to be *A. sylvaticus* is doubtful (Mežžerin & Zykov 1991).

Also in other parts of Palaearctic region, urban niche is occupied by related forms of *Apodemus* (Russian Far East: *A. agrarius mantchuricus*, Kostenko 1984, Japan: *A. speciosus*, Takatsu 1976), or in North America by species of the genus *Peromyscus* (Syracuse: VanDruff & Rowse 1986), which represent an ecological equivalent of *Apodemus* in America (Montgomery 1989).

#### *Apodemus flavicollis* (Fig. 10)

The Yellow-necked mouse was recorded in 26 localities. Its distribution, restricted to forest stands on the periphery of Prague, reminds to that of *C. glareolus*, however, it is distinctly more limited. The causes of its absence in some parks and forests are unclear. It can be attributed to island effects as well as to possible competition with *A. sylvaticus*.

NOTE. The discrimination between *A. sylvaticus* and *A. flavicollis* was made according to the hind foot length, coloration, and if necessary also according to the upper molar length. Due to relatively great size differences between these two species in Prague, it seems that only a small, unimportant fraction of animals should be determined erroneously.

#### *Micromys minutus* (Fig. 11)

Harvest mouse is the most rarely collected species. It was recorded from 8 localities only. We suppose this species to be actually more common, its limited presence in our material may be probably caused by its low trappability in the commonly used snap traps. According to available records, the species seems to be absent in central parts of the city.

#### *Mus musculus* (Fig. 12)

House mouse is the only true commensal species inhabiting buildings throughout the year. It was recorded from 40 localities distributed in the whole territory of Prague. Being restricted to human settlements, this species is lacking in numerous samples collected in natural habitats. Its occurrence in such places, far from any building, which was found in several cases should be attributed to capture of dispersing animals. In the Czech Republic, stable outdoor populations of the House mouse are reported from Southern Moravia only (Pelikán 1974).

NOTE. Regardless to the presence of contact zone between *Mus musculus* and *Mus domesticus*, most of the Czech territory is inhabited by the species *M. musculus*. According to phenotypic signs (coloration, tail length etc.), it is evident that the Prague population belongs also to this species. It is to be noted here, that mice derived from wild populations in Prague were repeatedly used in genetic research (Forejt & Iványi 1974, Forejt et al. 1988, Micková & Iványi 1976,

Deimling et al. 1988, Redi et al. 1990, Forejt et al. 1991) and even inbred strains were established (Pavljuková & Forejt 1981). All the above results obtained using biochemical and genetic methods confirmed that Prague population belongs without doubts to *M. musculus*. On the other hand, occurrence of escaped laboratory mice found in at least two localities (No.5 Zoopark, No.54 Botanical Garden & Albertov) may result in local introgression into wild population.

### Concluding remarks

According to the pattern of their distribution in Prague, treated species can be divided into following two groups:

1) *Crocicidura suaveolens*, *Apodemus sylvaticus*, *Mus musculus* and *Microtus arvalis* are widely distributed in the whole Prague territory including the central part.

2) Other species could be sorted into following order according to their decreasing ability to penetrate to the centre of the city: a) *Sorex araneus*, b) *Clethrionomys glareolus*, c) *Apodemus flavicollis*, d) *Sorex minutus*, *Neomys fodiens* and *Micromys minutus*. The Pine vole, *Pinymys subterraneus* cannot be included into this evaluation, because as evident, a local limit of its distribution passes just through the Prague area.

While the presence or absence of species of the former category in a particular locality seems to be almost fully determined by the presence or absence of suitable habitats, it is apparently not the case in species of the later category. In parks and cemeteries situated near the city centre they were frequently found to be absent even in places, which evidently were suitable from the point of view of their typical ecological requirements. Consequently, their absence in these localities surrounded by built up areas should be attributed to island effects. Among most conspicuous examples belong, e.g., the absence of both *Clethrionomys glareolus* and *Apodemus flavicollis* in the locality No 96 (Stromovka) as well as absence of *Sorex araneus*, *C. glareolus* and *A. flavicollis* in localities Nos 88 (Petřín) and 47 (Strašnice - Židovské hřbitovy).

However, it has to be remarked here that in many cases the possibility, that absence of the species is caused by habitat selection cannot be simply ruled out. It could be expected especially in species possessing more specific habitat requirements as are, e.g., *Neomys fodiens*, *Micromys minutus* and possibly also *Sorex minutus*.

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## Composition and seasonal changes of soil nematode community in a Central European oak forest

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Soil nematodes, community composition, seasonal changes, oak forest, South Bohemia

**Abstract.** The structure and dynamics of soil nematode community were studied at 60-70 years old oak forest in South Bohemia in 1986-1987. A total of 104 species was found, *Rhabditis maupasi* group, *Acrobeloides nanus* and *Filenchus minutus* were the most abundant nematodes. The mean abundance of the total community was  $1.27 \times 10^6 \text{ ind.m}^{-2}$ , the mean biomass  $1.59 \text{ g.m}^{-2}$ . Bacteriophages, mycophages and omniphages dominated in the abundance, omniphages and bacteriophages in the biomass.

Free-living and parasitic nematodes are an important group of invertebrates in terrestrial ecosystems. Soil nematodes in woodland sites reach abundance ranging from 255 to  $29,800 \times 10^3 \text{ ind.m}^{-2}$  and biomass from 75 to  $15,200 \text{ mg fw.m}^{-2}$  (Sohlenius 1980). Majority of nematodes in forest ecosystems belongs to bacteriophagous animals, omniphagous and predaceous species have the greatest biomass (Wasilewska 1979). Proportion of mycophagous and phytophagous nematodes to the total nematode abundance is variable.

Ecological studies on nematodes in forest ecosystems often deal with functional (trophic) groups of nematodes and interactions between genera or species with respect to their life strategies were paid less attention. The aim of this study was to analyse composition and seasonal changes of a nematode community in a Central European oak forest with a view to particular species and genera and their biology.

### MATERIAL AND METHODS

Investigations were carried out in an oak forest (60-70 years old) in South Bohemia near Netolice village,  $49^{\circ}04'N$ ,  $14^{\circ}11'E$ , 486 m a.s.l., square code 6951 in the network of squares on the map of the Czech Republic for faunistic research. Long-term mean annual air temperature in the region is  $7.3^{\circ}C$ , precipitation 602 mm. The seasonal changes of air temperature and precipitation in 1986-1987 are given in Fig.1. The dominant tree was *Quercus robur* L., accompanied by sparse *Tilia cordata* Mill., *Fraxinus excelsior* L., *Picea abies* (L.) Karst., *Acer pseudoplatanus* L. and *Fagus sylvatica* L.. The constant species in the undergrowth were *Oxalis acetosella* L., *Sanicula europaea* L., *Viola reichenbachiana* Jord., *Veronica chamaedrys* L. Soil type is a silt loam cambisol, 10.2% clay ( $<1\mu$ , wet wt), 40.0% sand ( $10-250\mu$ , wet wt). The values of  $pH(H_2O)$  (soil:H<sub>2</sub>O = 1:5) in litter, humus layer, and B-horizon were 5.4, 5.2, and 4.4, respectively. Mean organic carbon ( $C_{org}$ ) content was about 5% in 0-5 cm and 2% in 5-10 cm.

Soil samples were taken in approximately monthly intervals in January-December 1986 and in April-December 1987 using a cylindrical corer with an area of  $1 \text{ cm}^2$  (inner diameter 1.2 cm) in 10 replicates to the depth of 10 cm. Soil samples were divided into 0-5 cm and 5-10 cm subsamples. Nematodes were isolated from the soil by means of the modified Baermann funnel method for 24 hrs. Animals were fixed by hot FAA, temporary and



Table 1 Mean abundance ( $\times 10^3 \text{ ind m}^{-2}$ ) of soil nematodes in oak forest, bold - constant species (C50-100%)

	1986	1987
order MONHYSTERIDA		
1 <i>Eumonhystera vulgaris</i> (de Man, 1880)	5.8	8.1
2 <i>Eumonhystera</i> Andrassy, 1981 sp	0.9	-
3 <i>Geomonhystera villosa</i> (Butschli, 1873)	8.1	0.4
order ARAEOLAIMIDA		
4 <i>Cylindrolaimus bambus</i> Andrassy, 1968	-	0.3
5 <i>Anaplectus granulatus</i> (Bastian, 1865)	0.1	-
6 <i>Plectus acuminatus</i> Bastian, 1865	36.1	123.3
7 <i>Plectus curvatus</i> Bastian, 1865	0.2	-
8 <i>Plectus descens</i> Andrassy, 1985	0.1	0.2
9 <i>Plectus geophilus</i> de Man, 1880	1.0	3.4
10 <i>Plectus longicaudatus</i> Butschli, 1873	17.0	15.5
11 <i>Plectus parvus</i> Bastian, 1865	14.0	20.4
12 <i>Plectus rhizophilus</i> de Man, 1880	0.4	0.1
13 <i>Plectus sambesi</i> Micoletzky, 1915	2.5	16.8
14 <i>Plectus silvaticus</i> Andrassy, 1986	36.8	142.9
15 <i>Plectus cf. teleki</i> Mulk & Coomans, 1978	1.4	2.3
16 <i>Plectus</i> Bastian, 1865 sp 1	1.1	0.1
17 <i>Plectus</i> Bastian, 1865 sp 2	-	0.1
18 <i>Ceratoplectus arcticus</i> (Truskova, 1976)		
and	9.1	15.0
19 <i>Ceratoplectus armatus</i> (Butschli, 1873)		
20 <i>Wilsonema otophorum</i> (de Man, 1880)	10.0	0.4
21 <i>Fylocephalus auriculatus</i> (Butschli, 1873)	-	5.5
order TERATOCEPHALIDA		
22 <i>Metateratocephalus crassidens</i> (de Man, 1880)	3.1	0.9
23 <i>Teratocephalus costatus</i> Andrassy, 1958	-	0.4
24 <i>Teratocephalus luellus</i> Anderson, 1969	1.8	3.2
25 <i>Teratocephalus paratenius</i> Eroshenko, 1973	-	0.3
26 <i>Teratocephalus tenuis</i> Andrassy, 1958	0.2	-
27 <i>Teratocephalus terrestris</i> (Butschli, 1873)	8.9	1.6
order RILABDTIDA		
28 <i>Heterocephalobus elongatus</i> (de Man, 1880)	21.6	28.1
29 <i>Heterocephalobus loofi</i> Andrassy, 1968	0.8	0.1
30 <i>Cephalobus persegui</i> Bastian, 1865	0.9	0.4
31 <i>Cephalobus troglophilus</i> Andrassy, 1967	0.2	24.8
32 <i>Eucephalobus oxyuroides</i> (de Man, 1876)	0.5	-
33 <i>Eucephalobus striatus</i> (Bastian, 1865)	0.2	0.1
34 <i>Acrobeloides nanus</i> (de Man, 1880)	72.5	75.8
35 <i>Acrobeloides</i> (Cobb, 1924) sp	2.1	1.1
36 <i>Cervidellus</i> Thorne, 1937 sp	0.6	-
37 <i>Chiloplacus</i> Thorne, 1937 sp	0.1	-
38 <i>Panagrolaimus rigidus</i> (Steiner, 1866)	5.6	6.2
39 <i>Bursilla monhystera</i> (Butschli, 1873)	6.9	15.5
40 <i>Rhabdus maupasii</i> group Seurat in Maupas, 1919	125.1	353.9
41 <i>Bunonema reticulatum</i> Richters, 1905	1.4	0.5
42 dauer larvae	46.0	67.0

order	DIPILOGASTERIDA		
43	<i>Diplogaster</i> Schultze in Carus, 1857 sp.	0.4	0.4
order	APHELENCHIDA		
44	<i>Aphelenchus avenae</i> Bastian, 1865	0.5	-
45	<i>Paraphelenchus pseudoparietinus</i> (Micoletzky, 1922)	-	0.1
46	<i>Aphelenchoides saprophilus</i> Franklin, 1957	24.7	6.8
47	<i>Aphelenchoides subparietinus</i> Sanwal, 1961 and		
48	<i>Aphelenchoides pusillus</i> (Thorne, 1929) and	16.3	42.6
49	<i>Aphelenchoides</i> Fischer, 1894 sp		
50	<i>Aphelenchoides minus</i> Meyl, 1953	9.4	7.5
order	TYLENCHIDA		
51	<i>Filenchus discrepans</i> (Andrássy, 1954)	19.8	11.0
52	<i>Filenchus helenae</i> (Szozyguel, 1969)	30.3	19.2
53	<i>Filenchus minutus</i> (Cobb, 1893)	53.9	75.4
54	<i>Filenchus polyhypnus</i> (Steiner et Albin, 1946)	0.7	0.9
55	<i>Filenchus</i> (Andrássy, 1954) sp	8.8	3.4
56	<i>Aglenchus agricola</i> (de Man, 1884)	0.1	-
57	<i>Costenchus costatus</i> (de Man, 1921)	1.7	-
58	<i>Malenchus acarayensis</i> Andrássy, 1968 and		
59	<i>Malenchus bryophilus</i> (Steiner, 1914)	91.8	21.1
60	<i>Lelenchus leptosoma</i> (de Man, 1880)	-	3.5
61	<i>Cephalenchus megacephalus</i> Goodey, 1962	2.8	1.1
62	<i>Bitylenchus dubius</i> (Butschli, 1873)	0.2	-
63	<i>Helicotylenchus pseudobustus</i> (Steiner, 1914)	1.1	-
64	<i>Rotylenchus fallorobustus</i> Sher, 1965	0.3	-
65	<i>Pratylenchus crenatus</i> Loof, 1960	0.1	-
66	<i>Paratylenchus projectus</i> Jenkins, 1956	0.2	-
67	<i>Xenociconemella maci odora</i> (Taylor, 1936)	2.3	-
68	<i>Ditylenchus</i> (Filipjev, 1936) sp 1	32.8	108.5
69	<i>Ditylenchus</i> (Filipjev, 1936) sp 2	0.1	-
order	ENOPLIDA		
70	<i>Bastiania gracilis</i> de Man, 1876	0.9	2.2
71	<i>Prismatolaimus dolichurus</i> de Man, 1880	1.0	-
72	<i>Prismatolaimus intermedius</i> (Butschli, 1873)	14.9	9.1
73	<i>Tripyla affinis</i> de Man, 1880	-	0.1
74	<i>Tripyla filicaudata</i> de Man, 1880	1.9	3.1
75	<i>Alaimus meylli</i> Andrássy, 1961 and		
76	<i>Alaimus parvus</i> Thorne, 1939 and	6.8	4.7
77	<i>Alaimus primitivus</i> de Man, 1880 and		
78	<i>Alaimus</i> de Man, 1880 sp		
79	<i>Paramphidelus dolichurus</i> (de Man, 1876)	0.2	-
80	<i>Amphidelus pseudobulbosus</i> Altherr, 1953	-	0.1
order	MONONCHIDA		
81	<i>Clarkus papillatus</i> (Bastian, 1865)	9.2	10.1
82	<i>Coomansus parvus</i> (de Man, 1880)	0.9	
83	<i>Prionchulus punctatus</i> (Cobb, 1917)	24.7	22.1

84. <i>Mylonchulus</i> (Cobb, 1916) sp.	-	0.3
85. <i>Anatonchus tridentatus</i> (de Man, 1876)	0.3	-
order: DORYLAIMIDA		
86. <i>Nygolaimus</i> Cobb, 1913 sp.	0.2	-
87. <i>Prodorylaimus paralongicaudatus</i> (Micoletzky, 1925)	0.8	-
88. <i>Mesodorylaimus bastiani</i> (Bütschli, 1873)	43.9	84.6
89. <i>Eudorylaimus carteri</i> (Bastian, 1865)	36.7	46.0
90. <i>Eudorylaimus centrocercus</i> (de Man, 1880)	-	0.1
91. <i>Eudorylaimus parvus</i> (de Man, 1880)	15.7	14.0
92. <i>Eudorylaimus</i> Andrassy, 1959 sp.	2.1	0.4
93. <i>Thonus ettersbergensis</i> (de Man, 1885)	1.1	6.0
94. <i>Thonus</i> Thorne, 1974 sp.	3.6	0.3
95. <i>Dorydorella pratensis</i> (de Man, 1880)	0.1	-
96. <i>Aporcelaimellus obscurus</i> (Thorne et Swanger, 1936)	69.8	34.9
97. <i>Pungentus thornei</i> Goodey, 1943	0.9	0.1
98. <i>Paractinolaimus macrolaimus</i> (de Man, 1884)	2.1	0.6
99. <i>Oxydirus oxycephalus</i> (de Man, 1885)	0.9	-
100. <i>Tylencholaimus minimus</i> de Man, 1876	-	0.1
101. <i>Tylencholaimus mirabilis</i> (Bütschli, 1873)	11.6	5.0
102. <i>Tylencholaimus stecki</i> Steiner, 1914	30.8	33.8
103. <i>Diphtherophora</i> de Man, 1880 sp.	0.1	-
104. <i>Trichodorus</i> Cobb, 1913 sp.	0.4	-

permanent mounts were made by the glycerol-ethanol method (Šály 1983). All nematodes in samples were counted and identified simultaneously.

The biomass was estimated for 50 adult specimens of each species (excluding those with low abundance) according to Andrassy (1956). The biomass of juveniles was calculated as a half of the adult value (Šály 1975). Diversity was evaluated using the number of species and the index of species diversity  $H'(\ln_e)$  according to Shannon & Weaver (1949). Species having their constancy C50-100% represented the characteristic species combination of community. Nematodes were divided into trophic (ecological) groups as follows: bacteriophages

Table 2. Mean characteristics of soil nematode community in oak forest, A - abundance ( $10^3 \text{ ind. m}^{-2}$ ), B - biomass ( $\text{mg. m}^{-2}$ )  $H'$  - index of diversity, CL - confidence limits ( $P=0.05$ )

	1986		1987	
	A	B	A	B
Bacteriophages	467	234	950	714
Mycophages	288	17	301	19
Phytophages	10	2	1	+
Omniphages	221	1195	227	787
Predators	37	123	36	97
total nematodes	1023	1571	1515	1617
CL	$\pm 410$	$\pm 450$	$\pm 610$	$\pm 590$
% of adults	28.2		22.6	
number of species	92		76	
$H'$	3.39		2.96	

(species 1-43, 70-72, 75-80 in Tab.1), mycophages (i.e. fungal + facultative plant feeders) (44-55, 58-60, 68, 69), phytophages (56, 57, 61-67), omniphages (87-104), predators (73, 74, 81-86). Pearson correlation coefficients ( $r_p$ ) were calculated between the nematode abundance and soil moisture or temperature, Spearman rank correlation coefficients ( $r_s$ ) were calculated between the abundance and air temperature or precipitation. Dendrograms were produced for genera presence (faunistic similarity) and for  $\log(x+1)$  genera abundance (coenotic similarity) by Euclidean distance and Ward's clustering algorithm, program CLUSTAN (Wishart 1981). The total material studied was about 22 000 individuals. Nematode material is deposited with the author in the Institute of Soil Biology AS CR.

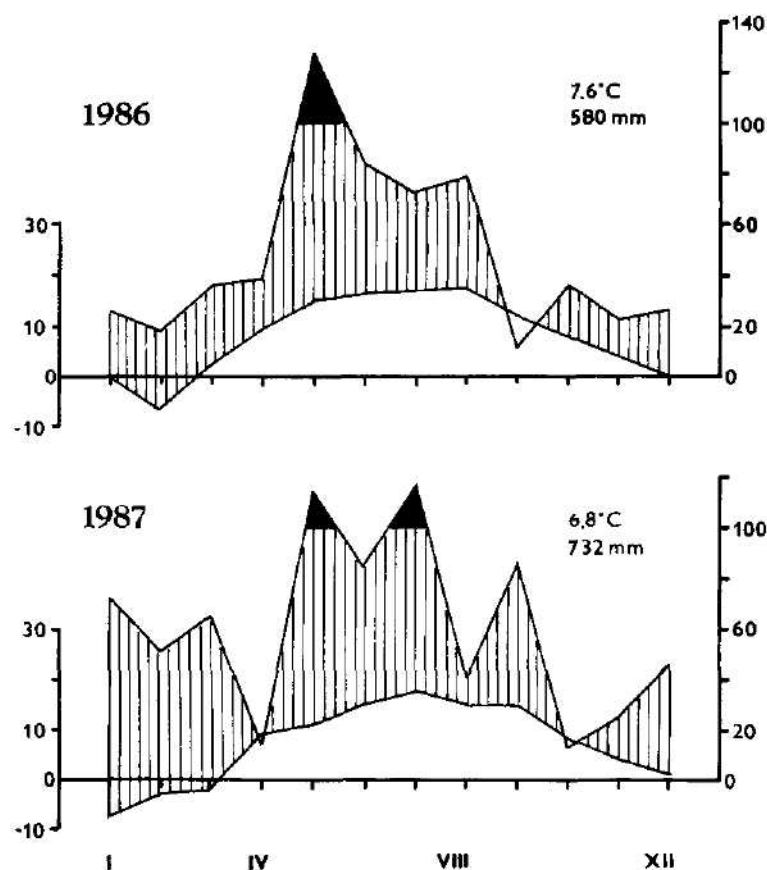


Fig. 1. Seasonal changes of air temperature and precipitation.

## RESULTS

A total of 104 species of nematodes were found in the soil of the oak forest. Three species, *Rhabditis maupasi*, *Acrobelodes nanus* and *Filenchus minutus*, dominated in both years. *Aporcelaimellus obscurus* and *Malenchus bryophilus* + *acarayensis* were dominant in 1986, while *Plectus acuminatus*, *Plectus silvaticus*, *Ditylenchus* spp. and *Mesodorylaimus bastiani* dominated in 1987. There were 15 species in the characteristic species combination of the community in 1986 and 16 species in 1987 (Tab.1). The highest biomass was established for the species

*A. obscurus*, *Eudorylaimus carteri*, *P. silvaticus*, *P. acuminatus*, *Prionchulus punctatus* and *M. bastiani*. The mean value of the index of species diversity  $H'$  was higher in 1986 (3.39) than in 1987 (2.96).

The mean abundance of nematode community in 1986 and in 1987 was  $1.02 \pm 0.41 \times 10^6$  ind.m<sup>-2</sup> and  $1.52 \pm 0.61 \times 10^6$  ind.m<sup>-2</sup>, respectively (Tab.2). In both years, the peak of abundance (0-10 cm) was found in August. High population densities of nematodes were also observed in January 1986 and in November 1986. In 1987, the highest abundance was found in April (Fig.2). In the soil layer of 5-10 cm, the seasonal changes of nematode abundance showed two peaks in

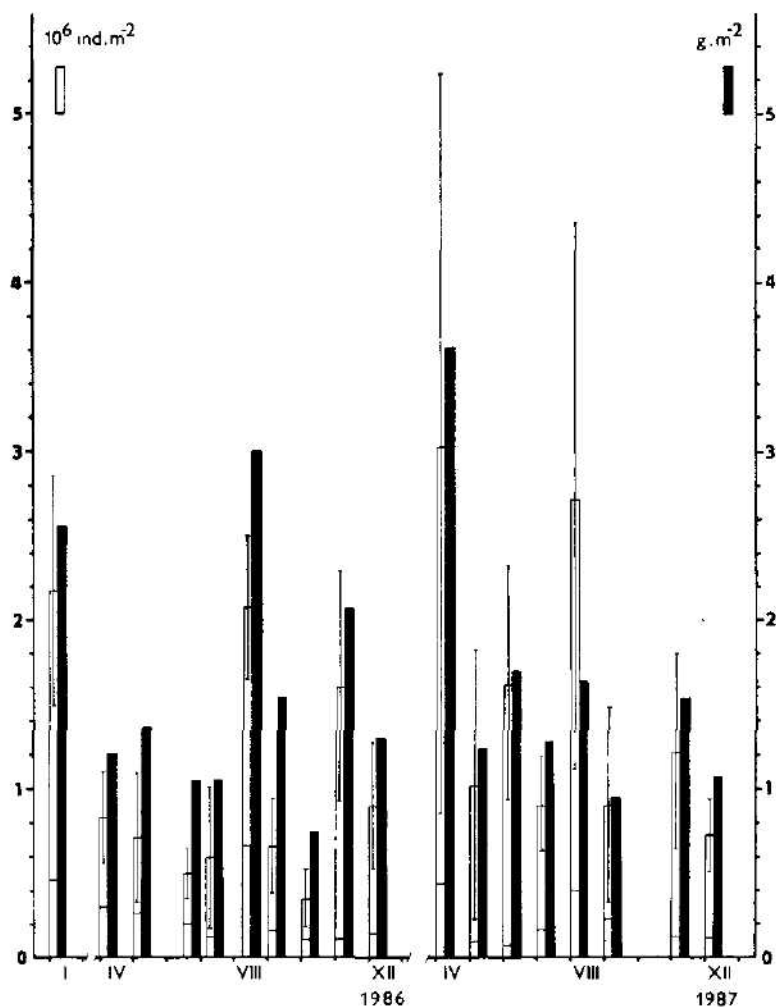


Fig. 2. Seasonal changes of abundance (white bars) and biomass (black bars) of nematodes, upper part of the white bars is the abundance in the soil layer of 0-5 cm, under part in the layer of 5-10 cm, abscissas - confidence limits ( $P = 0.05$ ).

both years (Fig.2). The abundance in this soil layer depended upon air temperature in the period June - December ( $r_s 1986 = +0.89$ ,  $n=7$ ;  $r_s 1987 = +0.66$ ,  $n=6$ ). The seasonal changes of abundance in the soil layer of 0-5 cm in 1987 was correlated with the soil moisture ( $r_p = +0.70$ ,  $n=8$ ).

The majority of nematodes preferred the upper parts of the soil horizon including leaf litter. In 1986 and 1987, 73.8 % and 86.0 % of nematode specimens were found in the layer of 0-5 cm, respectively.

The mean biomass of nematodes in 1986 and in 1987 was  $1.57 \pm 0.45 \text{ g.m}^{-2}$  and  $1.62 \pm 0.59 \text{ g.m}^{-2}$ , respectively. In the first year the peaks of biomass coincided with the peaks of abundance,

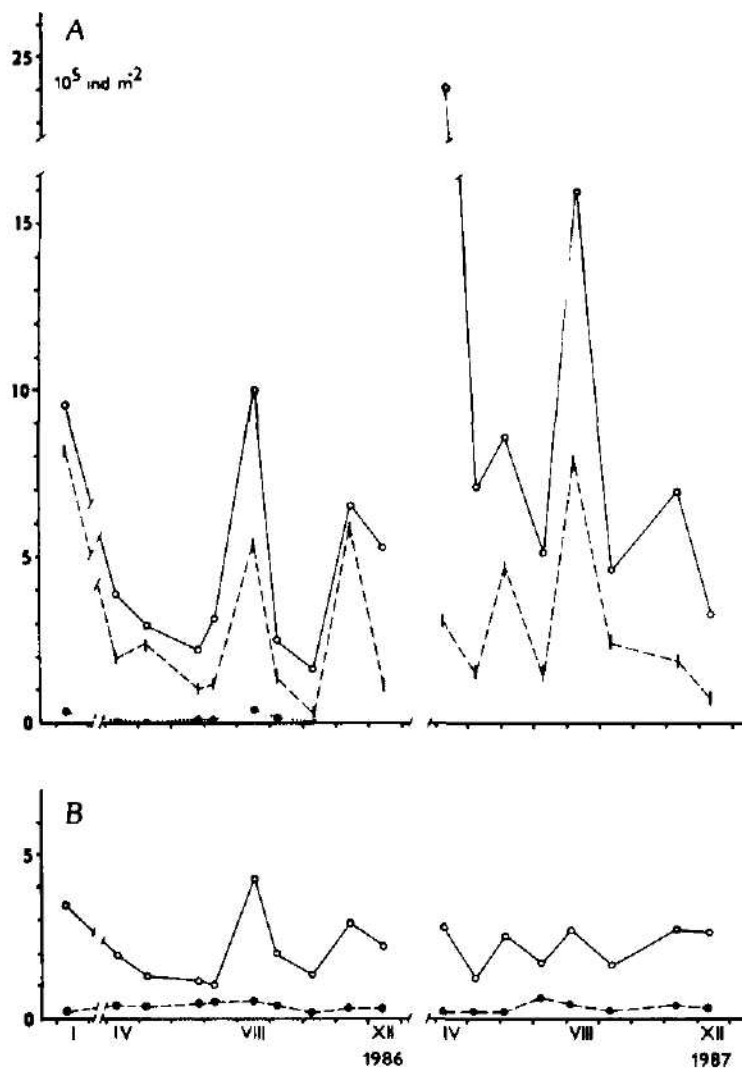


Fig. 3. Seasonal changes of abundance of ecological groups in nematode community.  
A. bacteriophages - solid line, mycophages - broken line, phytophages - dotted line  
B. omniphages - solid line, predators - broken line.

in the second year, conspicuous maximum of biomass was observed in April (Fig.2). The mean individual biomass of nematode specimen was significantly lower in 1987 ( $1.15 \pm 0.19 \mu\text{g}$ ) than in 1986 ( $1.70 \pm 0.24 \mu\text{g}$ ). The mean specimen biomass did not decrease under  $1 \mu\text{g}$  in 1986, but in August 1987 it was only  $0.60 \mu\text{g}$ . This decline probably reflected generally lower biomass of nematode specimen in 1987 compared with its value in 1986; a high abundance of nematodes in 1987 was caused by the population increase of smaller species and juveniles. The adult specimens represented 28 % (21 % - 38 %) of nematode community in 1986 and 23 % (13 % - 28 %) in 1987.

Three ecological groups dominated in 1986 and in 1987: bacteriophages (46% and 63% of the total abundance, respectively), mycophages (28% and 20%) and omniphages (21% and

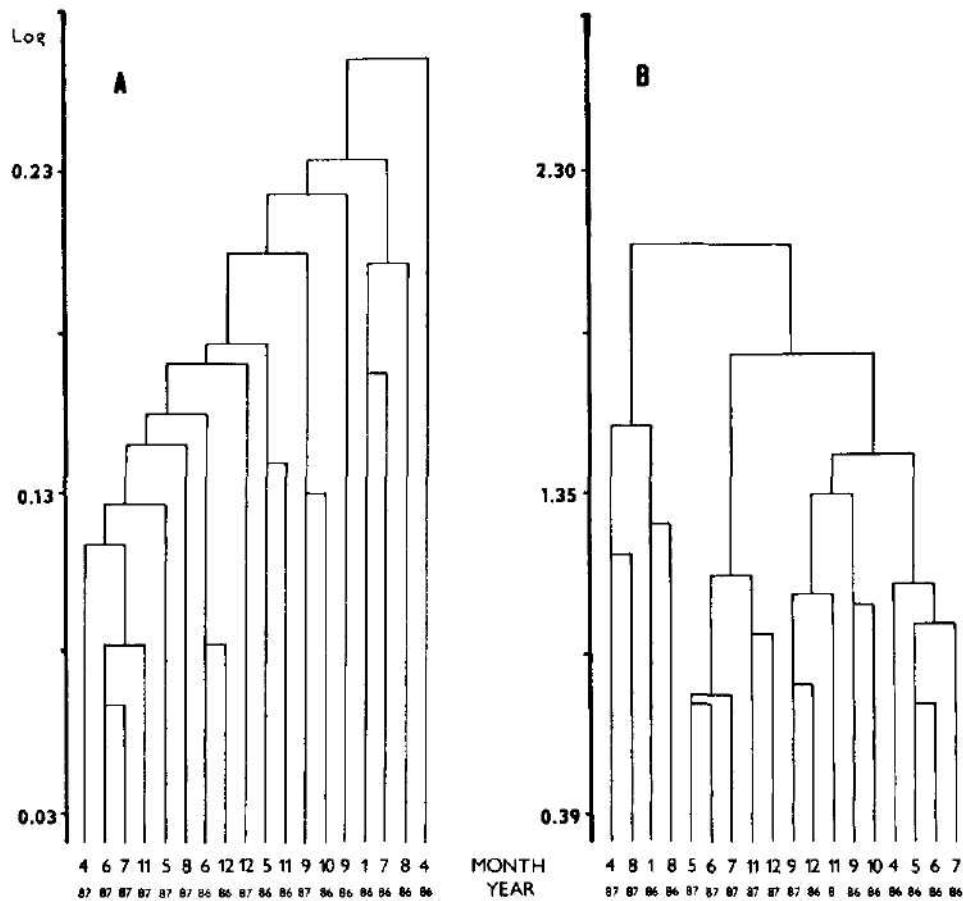


Fig. 4. Cluster analysis of soil nematodes  
A: genera presence  
B:  $\log(x+1)$  genera abundance.

15%). Omniphages represented 76% of nematode biomass in 1986 and 49% in 1987. The biomass of bacteriophages was 15% in 1986 and 44% in 1987 (Tab. 2). Seasonal changes of nematode trophic groups are shown in Fig. 3. Fluctuations in abundance of bacteriophagous



nematodes were similar to those of the total nematode community in both years. Three peaks of mycophagous nematodes was found in 1986, one peak in 1987. High population densities of omniphagous nematodes appeared in January, August and November 1986, but in 1987 abundance of omniphages fluctuated and no distinct maxima or minima were observed.

Three bacteriophagous genera were dominant in 1986 and 1987 as follows: *Plectus* (12% and 21% of the total nematode abundance), *Acrobeloides* (7% and 5%) and *Rhabditis* Dujardin, 1845 (12% and 23%, respectively). The genus *Plectus* had three peaks of abundance in 1986 (January, August, November-December), but in 1987 its abundance decreased from April to December. Similar changes were observed in the abundance of the genus *Rhabditis*. The abundance peaks of the genus *Acrobeloides* was found in August in both years and in January 1986.

Among mycophagous genera, the genus *Filenchus* was dominant in both years 1986 and 1987 (11% and 7% of the total nematode abundance, respectively). The genus *Malenchus* Andrassy, 1968 dominated (9%) in 1986, and the genus *Ditylenchus* (7%) in 1986. The highest abundance of the genus *Filenchus* was in January 1986 and in August (both years). The genus *Malenchus* reached the maximum of abundance in January 1986, the genus *Ditylenchus* in April 1987, and the genus *Aphelenchoides* in August 1987.

Omniphagous genera *Aporcelaimellus* Heyns, 1965 and *Eudorylaimus* dominated in 1986 (7% and 6% of the total nematode abundance, respectively). The genus *Mesodorylaimus* Andrassy, 1959 was dominant in 1987 (6%).

#### DISCUSSION

The nematode community in the oak forest studied was characterized by a high number of species. For example, Solovyeva (1986) found 43 - 118 species of nematodes in oak (or mixed oak) forests in the European part of the former USSR, Arpin (1975) determined 22 species in France, and Bassus (1962) and Volz (1951) gave data concerning 75 and 50 species in oak forests in Germany. Bartošová & Háněl (1994) determined 98 species in an oak-hornbeam wood in Central Bohemia. Relatively low number of nematode species (50) in the oak-hornbeam forest was found by Šály (1973, 1975) in Slovakia.

The abundance of nematodes in oak-dominated forests usually varies from 1 to 5 million individuals per m<sup>2</sup> (Arpin 1975, Arpin & Ponge 1986, Solovyeva 1986), and the mean abundance in the oak forest studied is in accordance with those data. Very high abundance ( $29.8 \times 10^6$  ind m<sup>-2</sup>) in an oak-ash forest in Germany was found by Volz (1951). The data on nematode biomass in oak forests are scarce. Šály (1975) give values from 3.95 to 13.45 g.m<sup>-2</sup>, Volz (1951) found 15.2 g m<sup>-2</sup>. Comparing available information, the biomass of nematodes of the oak forest studied was relatively low.

The seasonal changes of nematode abundance in forests are often characterized by two peaks (e. g. Šály 1980). The seasonal curve of abundance changes in the oak forest studied can be divided into two periods. In the first period (May-October) there was the peak of abundance in August in both years. The second period (November-April) was marked by nematode population maxima in January 1986 or in April 1987. An explanation of those changes can be given as follows. In relatively mild winter (January 1986; sufficient precipitation and accumulation of leaf litter in autumn 1985), certain nematode populations (*Plectus*, *Rhabditis*, *Acrobeloides*, *Aphelenchoides*, *Filenchus*, *Malenchus*) reached their peaks in early winter. If low temperature occurred (January 1987), the development of nematodes was probably retarded and nematodes (mainly *Plectus* and *Rhabditis*) realized their population maxima in early spring. The abundance peak in August was limited neither moisture nor temperature. Consequently, the seasonal changes of nematode community in the forest studied can be viewed in terms of "two-peak seasonal dynamics", but with a time-changeable increase of nematode abundance in the cold period of the

year. In lower altitudes the development of nematode population in oak forests can be limited by water shortage during summer (Bartošová & Háněl 1994).

The genera *Plectus*, *Rhabditis* and *Acrobeloides* were most important bacteriophagous nematodes, but these taxa differ in their life-history strategies. The generation time of the species in the family Rhabditidae is a few days at room temperature (Sohlenius 1968), Cephalobidae develop from egg to egg in 1-2 weeks (Sohlenius 1973), and the species of the family Plectidae complete their life cycle in more than 2 weeks (Overgaard Nielsen 1949, Yeates 1972, Maggenti 1961). Rhabditidae (bisexual, some species are hermaphroditic) survive unfavourable life conditions in the stage of non-feeding but motile "dauer larvae" (Golden & Riddle 1984), Plectidae (mostly parthenogenetic females) probably in eggs protected by cuticle with spines. The response of *Rhabditis* to an increase in bacterial populations consists in recovery from dauer larvae stage, that of *Plectus* probably in egg-hatching. The ubiquitous genus *Acrobeloides* has short generation time and is parthenogenetic.

The second most abundant group of nematodes were mycophages (or myco-phytophages). The abundance of the genus *Aphelenchoides* was relatively low although this genus was abundant in oak forests in Germany (Bassus 1962). Many species of the genus *Aphelenchoides* feed upon mycorrhizal fungi (Riffle 1970) and they can complete their life cycle in a few days. The mycophagous genus *Aphelenchus* Bastian, 1865 was almost absent at the stand in the present study whereas it was dominant in an oak-hornbeam forest in Slovakia (Šály 1973).

The species of the family Tylenchidae are abundant in oak forests, however, their feeding habits are insufficiently known. Yeates et al. (1993) in their comprehensive study on nematode food preferences considered Tylenchidae to be mainly plant feeders. On the other hand, Wood (1973) cultivated *Tylenchus* Bastian, 1865 spp. on fungi and Magnusson (1983) observed and documented feeding *Tylenchus* and *Malenchus* upon mycorrhizal fungi. The abundance of plant feeding Tylenchidae species (*Aglenchus agricola*, *Coslenchus costatus*, *Cephalenchus megacephalus*) was very low (Tab. 1) whereas the species of the genera *Filenchus* and *Malenchus* belonged to dominant nematodes. Very likely, majority of nematodes in the family Tylenchidae fed on fungi. Parasites on higher plants (Dolichodoridae, Hoplolaimidae, Pratylenchidae, Paratylenchidae and Criconematidae) represented negligible part of nematodes populations in the forest studied. Low population densities of phytoparasites was also found in an oak-hornbeam wood in Central Bohemia (Bartošová & Háněl 1994). In contrast to our data Šály (1973) found great population densities of phytoparasites in an hornbeam-oak forest in Slovakia, Arpin & Ponge (1986) in *Quercus petraea* and Arpin (1975) in *Quercus sessiliflora* woods in France.

Some nematodes in the order Dorylaimida (omnivores in this study) can be mycophagous, too. The species of the genus *Tylencholaimus* de Man, 1876 were cultivated on fungi (Wood 1973, Magnusson 1983). According to Yeates (1973) the genus *Aporcelaimellus* can feed upon autochthonous microflora. The genus *Mesodorylaimus* could also be mycophagous as it occurred in high densities in leaf litter of the forest studied. The species of order Dorylaimida are K-strategists or persisters (Bongers 1990) while mycophagous nematodes in the orders Aphelenchida and Tylenchida belong to r- or r/K strategists (or colonisers with C-p value about 2). It is evident that fungi and bacteria in the forest studied could be controlled by nematodes with different ways of life. As in populations of bacteriophagous nematodes competition between mycophagous species for food can be expected, however, there is little information on their interactions in field conditions.

Sohlenius (1985) studied influence of climatic conditions on nematode coexistence in coniferous forest soil (Central Sweden) in laboratory experiment and found that the competitive ability of the different species changes with moisture and temperature. Some genera (*Rhabditis*, *Aphelenchoides*) increased their population densities at low 2-5°C temperatures. Many species

are adapted to low temperatures, for example the nematodes of the family Plectidae are abundant in polar regions (Procter 1984). In the oak forest studied, great population densities of the genera *Plectus*, *Acrobeloides*, *Rhabditus*, *Aphelenchoides*, *Filenchus* and *Malenchus* were found in winter as well as in summer.

Precipitation, soil moisture and temperature were probably important factors influencing nematode community development, however the seasonal changes of abundance cannot be explained by soil microclimate only. The summer abundance peaks were found in August, nevertheless, high precipitation and air temperature above 10°C were in May, June and July, too. Nematode "peak assemblages" in summer (August 1986 and 1987) were similar to those in winter (January 1986) and in spring (April 1987) (Fig. 4B). High abundance of microbivorous nematodes indicated that development of soil and litter microflora could trigger off the development either eggs or dauer stages of many species. Activity of plant roots probably influenced soil microflora and indirectly the populations of various nematodes. Carnivorous mononchid nematodes, predacious microarthropods, tardigrades and nematophagous fungi can also significantly influence population densities of microbivorous species (Small 1987, Karg 1983, Nordbring Hertz & Jansson 1984). Very likely, seasonal changes in population densities of nematode species in the oak forest studied resulted from biological interactions in soil and, to a less extent, from moisture-temperature fluctuations.

#### SUMMARY

1. The species composition, trophic structure and seasonal changes of soil nematode community were studied at 60-70 years old oak forest in South Bohemia in 1986-1987.

2. A total of 104 species were found, *Rhabditus maupasi* group, *Acrobeloides nanus*, *Filenchus minutus* were dominant nematodes in both years. *Aporcelaimellus obscurus* and *Malenchus bryophilus* + *acarayensis* dominated in 1986, while *Plectus acuminatus*, *Plectus silvaticus*, *Ditylenchus* spp. and *Mesodorylaemus bastiani* in 1987.

3. The mean nematode abundance was  $1.27 \times 10^6 \text{ ind. m}^{-2}$ , the proportion of adult specimens was about 25%. Seasonal changes of nematode community was marked by two population maxima. The abundance peak in August was found in both years, other peaks were observed in January 1986 and in April 1987. The mean biomass of nematode community was  $1.59 \text{ g m}^{-2}$ .

4. Bacteriophages were the most abundant trophic group of nematodes followed by mycophages and omniphages. The abundance of parasites on higher plants was very low.

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***Scaphiostena* gen. n. and descriptions of two new species of the family  
Mordellidae from Oriental region (Coleoptera: Mordellidae)**

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**Taxonomy.** *Ophthalmocoenalia sirnadi* sp. n., *Scaphiostena schwendingeri* gen. n. and sp. n., key, Oriental region

**Abstract.** New monotypic Oriental genus *Scaphiostena* gen. n. with type species *Scaphiostena schwendingeri* sp. n. as well as *Ophthalmocoenalia sirnadi* sp. n. from Thailand are described.

INTRODUCTION

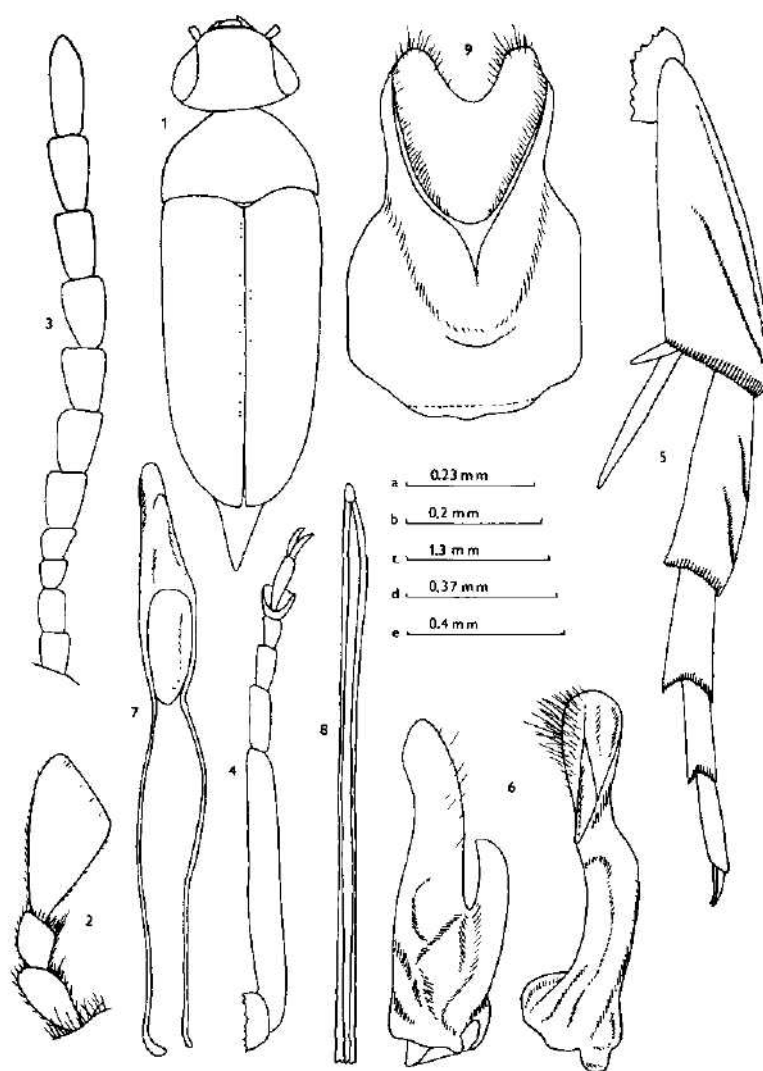
In the present paper the description of a new genus and species *Scaphiostena schwendingeri* gen. n. and sp. n. are given. This species with remarkable morphology was collected by a Swiss entomologist, Mr P. Schwendinger, into pitfall traps in the extreme climatic conditions of cold, rainy and misty mountain forests of Doi Inthanon in northern Thailand. The other species described below belongs to the genus *Ophthalmocoenalia* Ermisch hitherto known as a monotypic genus from tropical Africa. The discovery of the second species from Oriental region is therefore very important.

*Ophthalmocoenalia sirnadi* sp. n.

Completely red-brown. Pubescence golden-brown with silvery reflection on elytra. Body rather convex and parallel-sided with short and broadly conical pygidium (Fig. 1).

Head broadly convex, rather large, only slightly narrower than pronotum, prolonged anteriorly. Width/length ratio as 6.8 : 5.6. Eyes very large, pubescent, almost round, emarginated near insertions of antennae, particular facets medium-sized. Galea rather short, yellow-brown, on the tip with cirrose outgrowths, which form a very blunt point. Maxillary palpus with segments 2 and 3 of equal width, terminal segment elongate securiform, inner angle situated at its midlength (Fig. 2). Antennae rather long, with four basal segments equally broad, segment 1 by one third longer than 2, segment 3 only slightly shorter than 2 and equal to 4; segment 5 somewhat wider and by two thirds longer than 4, segments from the fifth one onwards becoming gradually narrower and 1.3 times (segment 5) to 1.7 times (segment 10) longer than wide, terminal segment oblong oval, 2.5 times longer than wide and by one fourth longer than the penultimate (Fig. 3).

Pronotum flatly convex, much wider than long (width/length ratio as 8.2 : 5.5), with only moderate collar-like projection anteriorly. Posterior lobe little vaulted. Sides in lateral view lightly emarginate, posterior angles moderately obtuse, rounded. Surface of pronotum finely and densely punctate.



Figs 1-9. *Ophthalmocoenalia strnadi* sp. n. (holotypus, male): 1 - general view; 2 - maxillary palpus; 3 - antenna; 4 - anterior tibia and tarsus; 5 - hind tibia and tarsus; 6 - left and right paramere; 7 - phallobase; 8 - penis; 9 - 8th internal sternite. Scale: a - 6; b - 2; c - 1; d - 7, 8; e - 4, 5, 9.

**Scutellum** small, broadly triangular.

**Elytra** convex, in anterior half parallel-sided, twice as long as their combined width, with dense and rather coarse rasp-like punctures.

**Pygidium** broadly conical, a little more than twice as long as hypopygium, and reaching only one fourth of the length of elytra.

**Anterior tibiae** quite straight, without a calf-like swelling and longer hairs. Anterior tarsus distinctly shorter than tibia, segment 4 deeply emarginate, by half shorter than the terminal segment, with onychium on its ventral side (Fig. 4). Mesotibia distinctly longer than tarsus.



Metatibia (Fig. 5) with one very oblique and long apical ridge (running from apical margin to the two thirds of the tibia length) and one distinct dorsal ridge. The first segment of posterior tarsus with two oblique ridges, following segments without ridges. Outer terminal spur reaching one third of the length of inner one.

Male genitalia as figured (Figs 6, 7, 8).

Length from the tips of mandibles to that of elytra 4.4 mm, to the tip of pygidium 5.2 mm.

TYPE MATERIAL. Holotypus, male, S. Thailand, Yala Distr., Betong, Gunung Can-dun-vill, 25.3-22.4 1993, leg. J. Horák. Deposited in coll. Horák, Praha.

NAME DERIVATION. The new species is dedicated to my friend Jan Štrnad, Prague.

DIFFERENTIAL DIAGNOSIS. *Ophthalmocoelia strnadi* sp. n. is the second species of a hitherto monotypic genus, proposed originally for *O. castanea* Ermisch, 1968 from tropical Africa (Ermisch 1968). The two species are very similar and differ especially by the body form, which is stouter, with elytra only twice as long as wide in *O. strnadi* sp. n., but markedly more slender, with elytra 2.2 times longer than wide, in *O. castanea*. Antennae in *O. strnadi* sp. n. are comparatively longer, almost twice as long as the head, whilst only 1.4 times longer than the head in *O. castanea*. Unfortunately, male genitalia of *O. castanea* are not figured in the original description.

### *Scaphiostena* gen. n.

Body (Fig. 10) short with rounded sides, large head and extremely long pygidium. Further very conspicuous and important characters are, small, coarsely faceted and pubescent eyes, very long antennae, terminal segment of maxillary palpus securiform (Fig. 14), penultimate segment of anterior and intermediate tarsus deeply bilobed, elytra very short, and broadly truncate at the apex, mesepisterna (Fig. 12) very short, short, but very oblique ridges on metatibia and on three segments of posterior tarsus.

The emarginate penultimate segment of anterior and intermediate tarsus as well as very broad pronotum (width/length as 6/4) suggest the close relationship of the new genus to the genera *Dellamora* Normand and *Pseudodellamora* Ermisch from the western Palaearctic. The genera can be distinguished according to the following key (according to Ermisch, 1950, modified). The form of the terminal segment of maxillary palpus and the coarsely faceted pubescent eyes in *Scaphiostena* gen. n. resemble also those of the genera *Glipostenoda* Ermisch and *Neomordellistena* Ermisch, but the new genus may be easily distinguished from the two latter genera by the form of elytra, pygidium and mesepisterna. The basic form of male genitalia (Fig. 11) does not differ, in fact, from that of *Mordellistena* Costa.

TYPE SPECIES *Scaphiostena schwendingeri* sp. n.

Incorporation of *Scaphiostena* gen. n. into the modified key to genera by Ermisch (1950):

- 72(65) Penultimate segments of both anterior and intermediate tarsi deeply emarginate or bilobed  
73(76) Pronotum much wider than long, 1.4 - 1.5 times wider than long. Body small, length including pygidium 2.5 - 3.5 mm  
74(75) Terminal segment of maxillary palpus in male more or less nut-shaped like in *Mordellochroa* Emery. Metatibia besides one apical ridge with two more lateral ridges. Metatibia with only one terminal spur. Eyes finely faceted and pubescent. W. Mediterranean, Cyprus.

*Dellamora* Normand

75(74) Terminal segment of maxillary palpus in both sexes securiform. Metatibia with two terminal spurs.

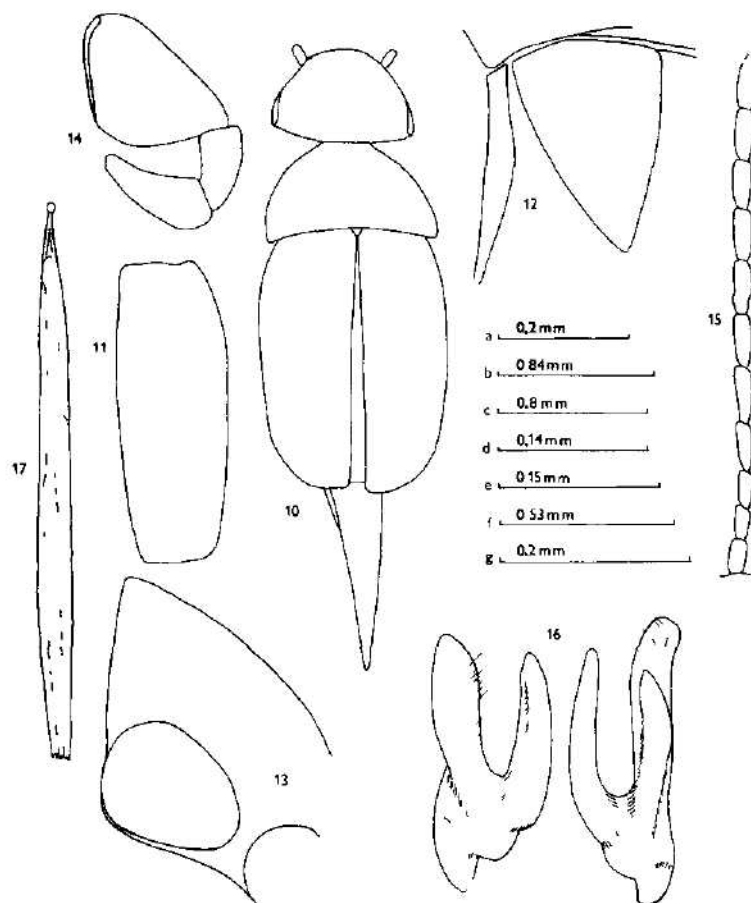
a(b) Elytra parallel sided, 2.4 - 2.5 times longer than their combined width, at the apex elongate, rounded. Mesotibia almost straight. Pygidium usually long, twice as long as hypopygium and reaching about one fifth of the length of elytra. Metatibia with only one lateral ridge. Eyes finely faceted and pubescent. W. Mediterranean, Caucasus.

*Pseudodellamoia* Ermisch

b(a) Elytra broad with arcuate sides, only 1.4 times longer than their combined width, broadly truncate at the apex. Mesotibia strongly curved inwards. Pygidium extremely long, nearly four times as long as hypopygium and reaching three fourths of the length of elytra. Metatibia, apart from one apical ridge, with 2-3 very oblique lateral ridges. Eyes very small, coarsely faceted and pubescent. Thailand.

*Scaphiostena* gen. n.

76(73) Continued (see Ermisch 1950)



Figs 10-17 *Scaphiostena schwendigeri* sp. n. (holotypus, male) 10 - general view, 11 - elytra, 12 - metepisternum, 13 - eye, 14 - maxillary palpus, 15 - antenna, 16 - left and right paramere, 17 - penis. Scale a - 13, b - 10, c - 11, d - 12, e - 14, f - 15, 17, g - 16.

*Scaphostena schwendingeri* sp. n.

Completely, yellow-brown. Strongly convex and rounded with extremely developed pygidium. Pubescence sparse, brightly golden yellow.

Head strongly convex, comparatively large, only slightly narrower than pronotum. Width : length as 7.6 : 6.5. Anterior portion of head capsule not prolonged anteriorly, clypeus as well as labrum very broad, labrum moreover extremely short. Eyes very small, oblong oval, without depression at the insertions of antennae (Fig. 13), finely faceted and pubescent (number of facets, due to the reduced eye size, very low). Entire posterior and lower margin of eye bordered, temples indistinct. Second segment of maxillary palpus in male elongate-clavate, only slightly wider than the third one; terminal segment broadly securiform, inner angle situated at its midlength (Fig. 14). Terminal segment in female only a little narrower. Antennae (Fig. 15) very long, equal in both sexes. Segment 2 as long as, but distinctly narrower than 1; 3 by one fourth shorter and a little narrower than 2; 4 as wide as, but by one third longer than 3; 5 more than three times longer than wide and by nearly fifth longer than 4; segments from 5 onwards gradually slightly abbreviated, segment 10 only twice as long as wide; terminal segment oblong oval, 2.6 times longer than wide and by one fourth longer than the penultimate. Ratio of the lengths of antennal segments as 10 : 9 : 12 : 15 : 13 : 13 : 12 : 12 : 12 : 16.

Pronotum flatly convex, transverse (width to length as 6 : 4), without the collar-like anterior prolongation; posterior lobe actually indistinct. Sides in lateral view (quite) straight, posterior angles obtuse, rounded.

Scutellum very small, broadly triangular, under normal conditions completely concealed by pronotum.

Elytra short and broad, moderately extending behind humera, only twice as long as their combined width. Apex of elytra broadly truncate, as broad as the elytral base (Fig. 11).

Pygidium more than three times longer than hypopygium, reaching one third of the total body length and two thirds of the length of elytra.

Anterior tibia in male gently curved inwards, without swelling on inner side and without longer hairs. The fourth segment of anterior and intermediate tarsi emarginate to about two thirds of its length, with anteriorly truncate onychium on ventral side. Mesotibia, apart from apical ridge, with 2 - 3 very oblique lateral ridges (the uppermost ridge mostly rudimentary). First segment of posterior tarsus with 2 - 3 oblique ridges, second and third segments with 2 ridges each. Outer terminal spur of metatibia reaching two thirds of the length of the inner one.

Mesepisterna (Fig. 12) very short, only by half longer than wide, with quite straight lateral margin, only slightly projecting between elytra and pronotum.

Male genitalia as figured (Figs 16, 17)

TYPE MATERIAL. Holotypus, male Thailand, prov. Chiang Mai, Doi Inthanon, 2500 m, 16-18.4.1987, leg. P. Schwendinger; Allotypus, female, the same data. Paratypes: 1 male, the same data as holotype, 1 male, 1 female, ditto, but 18.4-23.8.1987, 2 females (1 spec. without head and pronotum), ditto, but 17.7.1986 - 16.2.1987. Deposited in Museum d'Histoire naturelle, Geneve, two paratypes in my collection.

According to collector (personal communication by Dr I. Lobl) all species were captured into pitfall traps with the Formalin fixative, in which they have been accumulated during a very long period of time (see above data).

NAME DERIVATION. The new species is dedicated to the collector.

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techniques (X-rays, CT scans, sonograms, electrocardiograms), charts of geographic distribution of important parasitic diseases, and some laboratory procedures. Moreover, there are 11 full-page colour plates presenting the trophozoites and cysts of intestinal protozoa, malarial plasmodia in thin and thick blood films, and eggs of various intestinal helminths. In addition, there are 9 tables and many unnumbered reviews providing summarized information on protozoan and helminthic infections, and diseases transmitted by arthropods. Further on, presented are identification keys and characteristics, differential diagnosis, and suggested drug regimens. There is hardly any essential new information omitted in this volume. Based on tradition of 34 years and seven editions, this volume represents a readable, throughout updated, originally illustrated, and well-referenced textbook.

*Jindřich Jira*

(continuation from p. 150)

***Isometrus zideki* sp. n. from Malaysia and Indonesia, and a taxonomic position of  
*Isometrus formosus*, *I. thurstoni* and *I. sankariensis*  
(Arachnida: Scorpionida: Buthidae)**

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**Taxonomy, descriptions, new species, new combination. Scorpionida, Buthidae, *Isometrus*, Oriental region**

**Abstract.** *Isometrus* (*Reddyanus*) *zideki* sp. n. is described from Malaysia and Indonesia (Kalimantan). Taxonomic position of *Isometrus formosus* Pocock, *I. thurstoni* Pocock and *I. sankariensis* Tikader & Bastawade is discussed. *Isometrus formosus* is placed in the nominotypical subgenus *Isometrus* Hemprich & Ehenberg on the basis of distribution of pedipalpal trichobothria. The validity of the subgenera *Isometrus* and *Reddyanus* Vachon is affirmed, whereas the subgenus *Closotrichus* Tikader & Bastawade is considered to be a synonymum to the nominotypical subgenus. The type and only known species of the latter subgenus *I. sankariensis* is transferred in the subgenus *Isometrus*. A check list of all species of the genus *Isometrus* is included.

*Isometrus* (*Reddyanus*) *zideki* sp. n. (Figs 1-3, 9-12)

**TYPE MATERIAL.** Holotype: male, labelled Malaysia, Cameron Highlands, 1992 [collector anonymous], in the author's collection. Paratypes: one male (no. 1) and nine females (nos 2-10) labelled Malaysia, Cameron Highlands, 1992 (no. 2) and 1994 (nos 3-10) [collector anonymous], one female (No. 11) labelled Indonesia, Kalimantan, Nanga Pinoh, Pontang, leg. Jan Schneider 26 VII 1993. Female No. 3 is deposited in the Department of Invertebrate Zoology, National Museum (Natural History), Prague. All other paratypes are in the author's collection.

**TYPE LOCALITY.** A forest species occurring under tree bark.

**DERIVATIO NOMINIS.** Named after Jiff Zidek, a Czech paleontologist and zoologist at the New Mexico Tech University, Socorro, USA.

**DESCRIPTION.** The total length is 32.0 and 29.2 mm in the males and 25.7-30.2 mm in the females. Measurements of the carapace, telson, segments of the metasoma and segments of pedipalps, and numbers of pectinal teeth are given in Table 1. There are 11 and 12 pectinal teeth in the males and 10-12 in the females. For the position and distribution of trichobothria on the pedipalps see Figs 1-3. The base color is yellow to reddish brown with numerous black spots over the entire body. On the chelicerae the black pigment forms an irregular lattice. The carapace, legs, femur and patella of the pedipalps are spotted. The carapace has a well defined black spot around the median eyes, and the mesosoma bears three longitudinal stripes that, however, may not be well developed or readily apparent. The finger is darker than the manus, which is yellow to light reddish brown with minute black spots chiefly on the external surface. In the females the base color of the first three metasomal segments is yellow and that of the last two segments and the telson is reddish brown to black. The posterior halves of the first four metasomal segments

Table 1. Measurements in millimeters of the species described. The column denoted "Pectinal teeth" contains numbers of both left and right teeth separated by a colon

		<i>Isometrus (R.) zideki</i> sp. n. holotype male	<i>Isometrus (R.) zideki</i> sp. n. paratype No. 2 female
Total	length	32	28
Carapace	length	3.5	3.2
	width	3.7	3.5
Metasoma	length	21.2	16.6
	segment I	2.4	1.8
segm. II	width	1.5	1.3
	length	3.1	2.3
segm. III	width	1.5	1.3
	length	3.4	2.6
segm. IV	width	1.4	1.2
	length	4.0	3.0
segm. V	width	1.4	1.1
	length	4.9	3.7
telson	width	1.5	1.1
	length	3.4	3.0
Pedipalp	length	3.4	2.7
	femur	width	1.1
patella	length	4.0	3.4
	width	1.5	1.4
tibia	length	6.4	5.0
	manus	length	3.5
finger m	width	1.9	1.2
	length	3.5	3.2
Pectinal	teeth	11.11	10.11

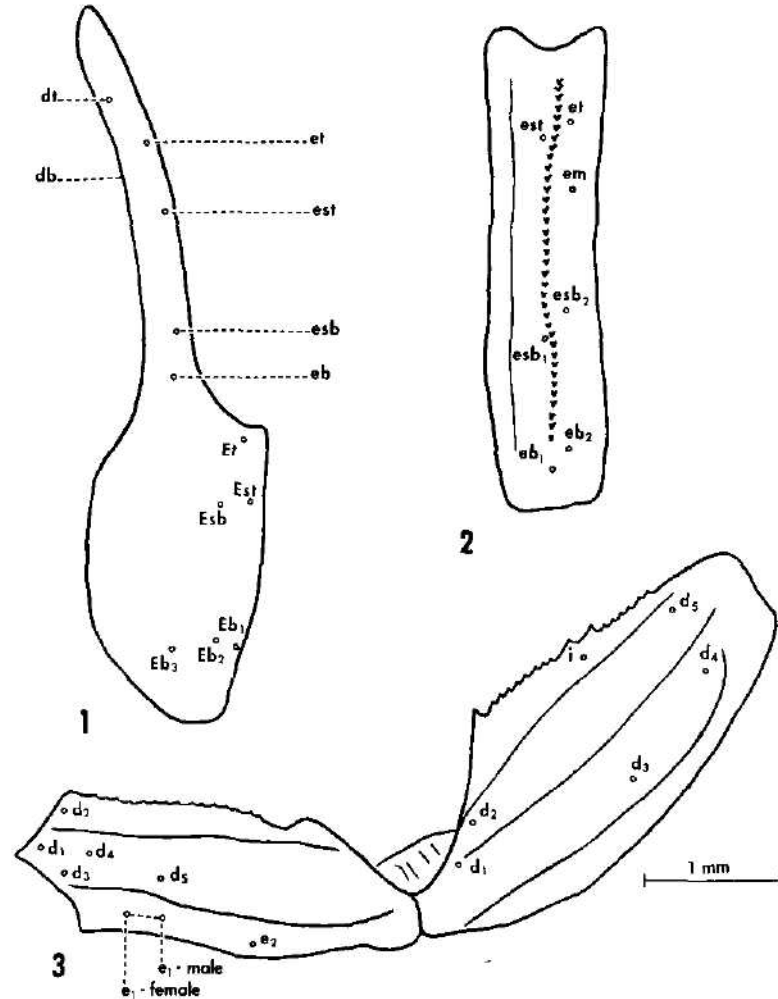
are spotted and darker, and the fifth segment is entirely black. In the males the metasoma is less spotted. The first three segments are yellow with but a few spots, the fourth segment is reddish brown to black, the fifth segments is black, and the telson is again reddish brown to black.

**AFFINITIES.** The species is characterized by distribution of trichobothria on the pedipalps (Figs 1-3), only two rows of granules on the subaculear tooth of the telson (Figs 9, 11), very thin metasoma in both sexes (Table 1), a well developed median keel on the underside of the fifth metasomal segment, and two well developed parallel keels on the undersides of third and fourth metasomal segments (Figs 10, 12). The space between these two keels contains a row of irregularly dispersed granules of uneven size, which are much less numerous in the males than in the females.

Geographically the nearest species of *Isometrus* is *I. formosus* Pocock, 1893 from Java. This species has not yet been placed into any subgenus. According to opinion of the author of this paper *I. formosus* is a member of the monotypic subgenus (see belows). In this subgenus belongs also *I. (I.) maculatus* (De Geer, 1778), which has so far been the only species known from Malaysia and Kalimantan. In contrast, *Isometrus zideki* sp. n. belongs in the subgenus *Reddyanus* Vachon, 1972 (Vachon 1972, 1976 and 1982) and appears to be most closely related to *I. (R.) heimi* Vachon, 1976 from New Caledonia, which has similar proportions and also bears only two rows of granules on the subaculear tooth of the telson. This character differentiates these two species very well from the majority of other species of the subgenus *Reddyanus*. *I. (R.) zideki* sp. n. differs from *I. (R.) heimi* in having 10-12 pectinal teeth (12-13 in *I. heimi*) and a pronounced median keel on the underside of the fifth metasomal segment in both sexes (Figs 10,

12; Vachon 1976, p.43, figs 12-13). Other differences can be seen in coloration, where for instance in the male of *I. (R.) zideki* sp. n. the fifth metasomal segment is entirely black.

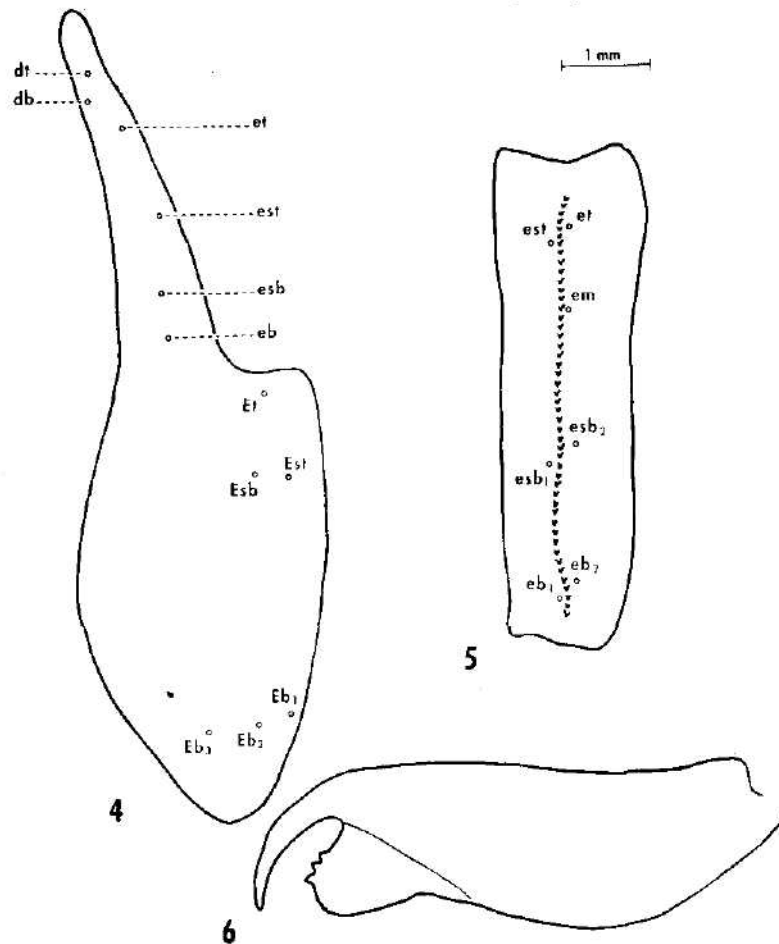
DISCUSSION. Twelve species of scorpions belonging to five families are known to occur in Kalimantan. They are *Isometrus (Reddyanus) zideki* sp. n., *Isometrus (Isometrus) maculatus* (De Geer, 1778), *Lychas shelfordi* (Borelli, 1904) and *Lychas hosei* (Pocock, 1890) of the family Buthidae, *Heterometrus (Heterometrus) longimanus* (Herbst, 1800) of the family Scorpionidae,



Figs 1-3. *Isometrus (Reddyanus) zideki* sp. n. (Paratypus No. 2). Fig. 1. Tibia, Fig. 2. Patella, Fig. 3. Patella and femur. Denoted is position of trichobothrium e1 in the holotypus (male). The second male (Paratypus No. 1) has trichobothrium e1 situated between d4 and d5, but closer to d5 than in the female. In Fig. 1. the first capital letters denote trichobothria situated on the manus; the first lower case ones, those situated on the fixed finger of pedipalp. Explanations: First letters: d, dorsal, e, external i, internal. Second, or second plus third letters: b, basal, sb, suprabasal, m, medial, st, subterminal, t, terminal. Numerals distinguish individual trichobothria of the same classification. Designation and description of trichobothria according to Vachon (1973).



*Liocheles australasiae* (Fabricius, 1775) (Vachon & Lourenco 1985) and *Liocheles waigiensis* (Gervais, 1844) of the family Ischnuridae (Koch 1977), *Chaerilus celebensis* Pocock, 1893, *Chaerilus variegatus* Simon, 1877, *Chaerilus chapmani* Vachon & Lourenco, 1985 (Vachon & Lourenco 1985) and *Chaerilus laevimanus* Pocock, 1899 (Pocock 1899) of the family Chaeriliidae, and *Parascorpiops montana* Banks, 1928 of the family Vaejovidae (Francke 1976).



Figs 4-6. *Isometrus (Isometrus) formosus* Pocock, 1893. Fig. 4. Tibia, Fig. 5. Patella, Fig. 6. Telson. In Fig. 4, the first capital letters denote trichobothria situated on the manus; the first lower case ones, those situated on the fixed finger of pedipalp. Explanations: First letters: d, dorsal, e, external. Second, or second plus third letters: b, basal, sb, suprabasal, m, medial, st, subterminal, t, terminal. Numerals distinguish individual trichobothria of the same classification. Designation and description of trichobothria according to Vachon (1973).

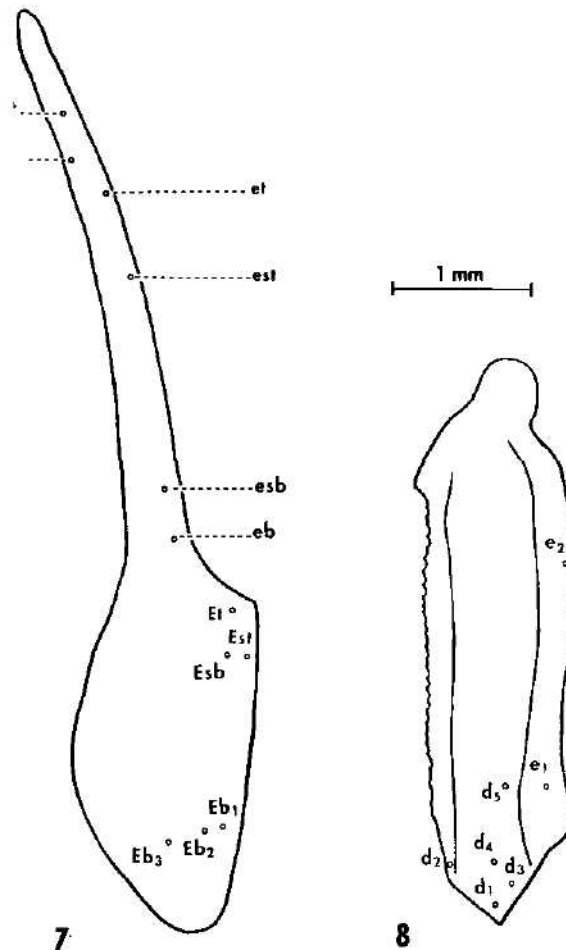
*Isometrus (Isometrus) formosus* Pocock, 1893 **comb. n.** (Figs 4-6)

*Isometrus formosus* Pocock, 1893: 88; Kraepelin, 1899: 67; Vachon, 1972: 177; Vachon, 1976: 39.

**MATERIAL EXAMINED.** A male - labelled: Java, Haldumulla, Buitenzorg, IV.1894, det. Pocock, deposited in collection of The Natural History Museum, London.

COMMENTS. The total length is 52.3 mm, of which the metasoma amounts to 34 mm. The distribution of the trichobothria on the pedipalps corresponds precisely to that given for the subgenus *Isometrus* by Vachon (1972, 1982). This species is very well characterized also by a pronounced subaculear lobe-like tooth (Fig. 6) with three rows of granules.

DISCUSSION. Kraepelin (1899) and Vachon (1972, 1976) listed this species only from Java and Sumatra, but Takashima (1948, 1950) found in the Tokyo Science Museum a male from Manokwari, New Guinea. According to Koch (1977) the New Guinea record is disputable, however, because the specimen may in reality belong to *I. melanodactylus* (C. L. Koch, 1867). Takashima (1950) characterized *I. formosus* by 10-13 (usually 11) pectinal teeth, whereas *I. melanodactylus* has 10-17 pectinal teeth (Koch 1977) and the specimen of *I. formosus* examined in this study has 14 pectinal teeth.



Figs 7-8. *Isometrus (Isometrus) sankaiensis* (Tikader & Bastawade, 1983). Fig. 7. Tibia, Fig. 8. Femur. In Fig. 7, the first capital letters denote trichobothria situated on the manus; the first lower case ones, those situated on the fixed finger of pedipalp. Explanations: First letters: d, dorsal, c, external. Second, or second plus third letters: b, basal, sb, suprabasal, st, subterminal, t, terminal. Numerals distinguish individual trichobothria of the same classification. Designation and description of trichobothria according to Vachon (1973).

*Isometrus (Isometrus) thurstoni* Pocock, 1893

*Isometrus thurstoni* Pocock, 1893: 297; Kraepelin, 1899: 67.

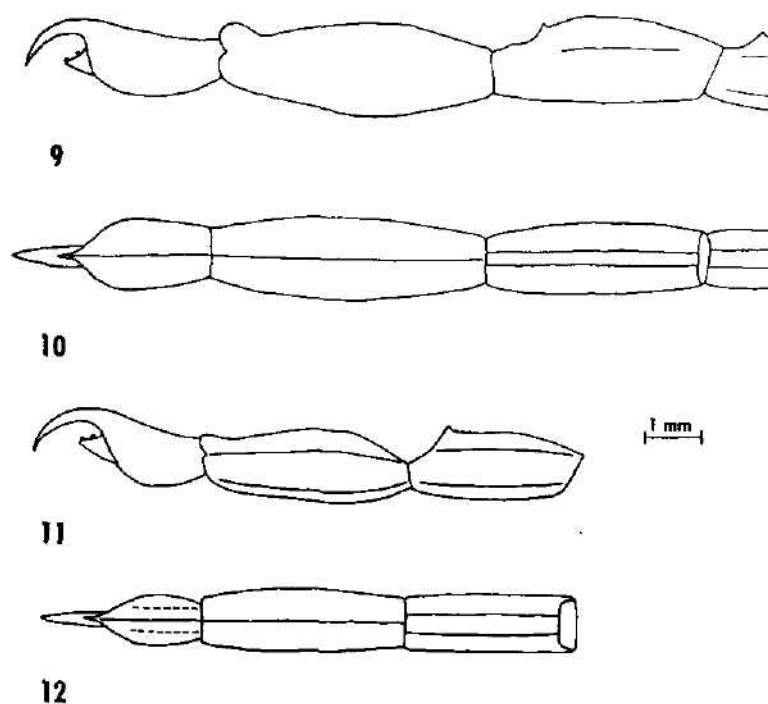
*Isometrus (Isometrus) thurstoni*: Vachon, 1972: 177; Vachon, 1976: 38.

*Isometrus (Reddyanus) thurstoni*: Tikader & Bastawade, 1983: 273.

**MATERIAL EXAMINED.** A female - labelled: India, Tamil Nadu, Mudumalai, leg. Roman Sauer 18.VI.1994, in the author's collection.

**COMMENTS.** The total length is 45.2 mm, of which the metasoma amounts to 27.3 mm. There are 16 pectinal teeth. Subgeneric characters entirely agree with those of the type subgenus *Isometrus* (Vachon 1972, 1982).

**DISCUSSION.** Vachon (1982) placed this species in the subgenus *Isometrus*, but Tikader & Bastawade (1983) transferred it into the subgenus *Reddyanus*. A revision of subgeneric characters listed and discussed by Vachon (1972, 1982) reaffirms the placement of this species in the subgenus *Isometrus*.



Figs 9-12. *Isometrus (Reddyanus) zideki* sp. n. Fig. 9 male (Holotypus), lateral view of telson and fifth and fourth segments of the metasoma. Fig. 10 male (Holotypus), ventral view of telson and fifth and fourth segments of the metasoma. Fig. 11 female (Paratypus No. 2), lateral view of telson and fifth and fourth segments of the metasoma. Fig. 12 female (Paratypus No. 2), ventral view of telson and fifth and fourth segments of the metasoma.

*Isometrus (Isometrus) sankariensis* Tikader & Bastawade, 1983 **comb. n.** (Figs 7-8)

*Isometrus (Closotrichus) sankariensis* Tikader & Bastawade, 1983 311

**MATERIAL EXAMINED** One female - labelled India, Kerala, Peryar, leg. Pavel Senft 15 IV 1993, Two females labelled India, Kerala, Munar env., Kalar Vall., leg. Roman Sauer 29-31 V 1994, in the author's collection

**COMMENTS** The specimen from Peryar was found at the base of a tree under bark, at approximately 900 m elevation. Its total length is 33.5 mm, of which the metasoma amounts to 21.5 mm. This specimen has 17 pectinal teeth. The females from Kalar reach 36.2 and 35.9 mm, of which the metasomas amount to 22.3 and 21.5 mm, respectively. Both specimens have 14 pectinal teeth. The characters of the species match the description of Tikader & Bastawade (1983), but the subgeneric characters do not differ in any way from those of the type subgenus *Isometrus* (Vachon 1972, 1982). The features of the subgenus *Closotrichus* do not differ from those of the subgenus *Isometrus*.

DISCUSSION

Vachon (1976) divided the 14 known species into two subgenera: *Isometrus* Hemprich & Ehrenberg, 1879 with the species *I. maculatus* (De Geer, 1778), *I. thurstoni* Pocock, 1893 and *I. madagassus* Roewer, 1934, and *Reddyanus* Vachon, 1972 with the species *I. melanodactylus* (C. L. Koch, 1867), *I. assamensis* Oates, 1888, *I. acanthurus* Pocock, 1889, *I. brachycentrus* Pocock, 1889, *I. rigidulus* Pocock, 1897, *I. vittatus* Pocock, 1900, *I. papuensis* Werner, 1916 [= n. syn. *I. melanodactylus* (C. L. Koch, 1867), Koch 1977 p. 156] and *I. heimi* Vachon, 1976. The remaining three species *I. basilicus* Karsch, 1879, *I. formosus* Pocock, 1893 and *I. twaitesi* Pocock, 1897, were not placed subgenerically. In 1982 Vachon placed *I. twaitesi* Pocock, 1897 and *I. basilicus* Karsch, 1879 in the subgenus *Reddyanus*, where he added also *I. besucheti* Vachon, 1982.

Tikader & Bastawade (1983) incorrectly transferred *I. thurstoni* from the monotypical subgenus into the subgenus *Reddyanus*, where they placed also *I. isadensis* Tikader & Bastawade, 1983 and *I. corbei* Tikader & Bastawade, 1983. They erected a new subgenus *Closotrichus* Tikader & Bastawade, 1983 containing the sole species *I. sankariensis* Tikader & Bastawade, 1983, and incorrectly transferred the type species of the genus *Isometrus*, *I. (I.) maculatus* (= *Isometrus (R.) europaeus*) into the subgenus *Reddyanus*. In so doing, they abolished the type subgenus *Isometrus* Hemprich & Ehrenberg, 1879.

Comparing the features characterizing subgenus *Closotrichus* with those characterizing subgenus *Isometrus*, I come to the conclusion that *I. sankariensis* (Tikader & Bastawade 1983) belongs in the subgenus *Isometrus* Hemprich & Ehrenberg, 1879, which is valid and best characterized by the features given by Vachon (1972 and 1982). The position of the *Isometrus* species which Tikader & Bastawade (1983) described as belonging in the subgenus *Reddyanus* ought to be re-examined. For this reason their placement in the subgenus *Reddyanus* is denoted by an asterisk in the following list of species of the genus *Isometrus*.

Check list of species of the genus *Isometrus* Hemprich & Ehrenberg, 1879

subgenus *Isometrus* Hemprich & Ehrenberg, 1879

= *Closotrichus* Tikader & Bastawade, 1983 **syn. n.**

1. *formosus* Pocock, 1893 **comb. n.** Indonesia (Java, Sumatra)

- 2 - *maculatus* (De Geer, 1778) South America, Antilles, USA (Florida), Costa Rica, Africa, Madagascar, Pakistan, India, Sri Lanka, China, Burma, Thailand, Laos, Cambodia, Malaysia, Indonesia, Australia, New Guinea
  - 1 - *Scorpio europaeus* Linnaeus, 1758
  - = *Isometrus europaeus* Lönnberg, 1897
  - = *Scorpio dentatus* Herbst, 1800
  - = *Scorpio americanus* Herbst, 1800
  - = *Buthus (Isometrus) filum* Hemprich & Ehrenberg, 1828
  - = *Lychas paraensis* C. L. Koch, 1845
  - = *Scorpio (Lychas) gabonensis* Lucas, 1858
  - = *Scorpio guineensis* Lucas, 1858
- 3 - *madagassius* Roewer, 1934 Madagascar
- 4 - *sankatensis* Tikader & Bastawade, 1983 **comb. n.** India (Kerala, Karnataka)
- 5 - *thurstoni* Pocock, 1893 India (Madhya Pradesh, Maharashtra, Andhra Pradesh, Tamil Nadu)

subgenus *Red dyanus* Vachon, 1972

- 1 - *acanthurus acanthurus* Pocock, 1899 India (Maharashtra), Himalayas
- 2 - *acanthurus loebli* Vachon, 1982 Sri Lanka
- 3 - *assamensis* Oates, 1888 Assam, India (Uttar Pradesh), Nepal, Himalayas
- 4 - *basilius* Karsch, 1879 Sri Lanka
- 5 - *besucheti* Vachon, 1982 Sri Lanka
- 6 - *brachycentrus* Pocock, 1899 India (Karnataka, Kerala)
- 7 - *heini* Vachon, 1976 New Caledonia
- 8 - *melanodactylus* (C. L. Koch, 1867) Australia, New Guinea
  - = *Isometrus melanodactylus inflatus* Glaueit, 1925
  - = *Isometrus gracilis* Thorell, 1877
  - = *Isometrus papuensis* Werner, 1916
- 9 - *rigidulus* Pocock, 1897 India (Madhya Pradesh)
- 10 - *twatesi* Pocock, 1897 Sri Lanka
- 11 - *vittatus* Pocock, 1900 India (Maharashtra, Tamil Nadu), Indochina
- 12 - *zideki* sp. n. Malaysia, Indonesia (Kalimantan)
- 13 - \* *corbeti* Tikader & Bastawade, 1983 India (Uttar Pradesh)
- 14 - \* *isadensis* Tikader & Bastawade, 1983 India (Maharashtra)

#### Acknowledgements

I thank the Natural History Museum, London, for lending me the specimen of *Isometrus formosus* Pocock, 1893 and Czech entomologists Jan Schneider and Roman Sauer of Prague, and Pavel Senft of Ostrava for providing me with specimens collected by them in Kalimantan and India.

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\*) see the text on the page 201

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## BOOK REVIEW

KUPCHELLA, CH E & HYLAND, MARGARET, C **Environmental Science. Living Within the System of Nature.** Third Edition Prentice Hall International a Company of Simon & Schuster, London, Sydney, Toronto Mexico, New Delhi, Singapore, Rio de Janeiro, Englewood Cliffs 1993 XXVII + 579 pages Format 210 x 280 mm Price softcover \$ 35 00 ISBN 0-13 027418 6

As stated in the preface, in the not too distant future, the environment will be required subject of matter for all college and university students. Environmental issues are already predominantly important throughout the world and critical to the future of human civilization, that we simply cannot have a world where leaders are ignorant of the dynamics of interaction between humans and the environment. Global ecological issues are critical for the future of human civilization. The crisis in solid waste disposal, debris washing up on coast beaches, worsening of the air quality, decreasing ozone in the ozone shield, threat of global warming and the "greenhouse effect", diminishing of fossil fuel, increasing contamination of groundwater, nuclear accidents, dying of trees, disappearing of tropical rainforest and wetlands, lakes afflicted by acid deposition, etc. The volume is organized into four parts and consists of 10 chapters. Numerous minglossaries inserted into the text present definitions and explain key terms associated with particular topics. Moreover, there are many "enrichment boxes" which are featured in the main text by frames and which highlight various ecological phenomena. There are also environmental career profiles. Each chapter concludes with a summary, concepts to remember, and references for further reading. The book is designed to be used flexibly: the chapters can be taken up in any order. Textual part is supported by 227 figures including diagrams, line drawings, schemes of ecosystems and material cycles in nature, individual procedures, landscape profiles and charts. Moreover, there are 75 tables, many unnumbered black and white photographs and four colour sheets which illustrate different biomes, landscapes and charts.

Part one (5 chapters) introduces basic principles of ecology which is defined here as the study how the living and nonliving things in the nature relate together. Discussed are the framework of ecology, energy in ecosystems, material cycles in living systems, populations and communities and evolution and ecology.

Part two (3 chapters) is concerned with human beings in the scheme of natural things. It explores the human need for energy and nutrients, mineral and water resources. The chapter on population, food and hunger presents two sections. In section A various aspects of human population growth are looked at. Section B outlines the food production, food distribution and economic development, and the impact of biotechnology on agriculture.

Part three (10 chapters) deals with impacts of human activities on health and the environment. Discussed are air pollutants and their sources, the effects of air pollution on humans, other organisms and ecosystems, control of air pollution, water pollution, land use and misuse, wildlife, wilderness, and biological resources, the problem of persistent hazardous materials in the ecosphere, waste disposal in the ecosphere, and environmental aspects of cancer.

Part four (2 chapters) summarizes topics covered up to this point, focusing on the roots of environmental problems. For solving this discussed are activities of various human institutions referring to religion, government, law, economy, education, science, medicine, and cities.

This book is based on tradition of two previous editions (1986, 1989). It is designed to be used by students headed for leadership positions in business, science, law, government, education, engineering, agriculture and other fields. Its approach is human centered, the term "environmental science" is broader than "ecology".

*Jindřich Jirá*



## Supplementary records of earthworms (Lumbricidae) in the Czech Republic

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### Faunistics, list, earthworms, Lumbricidae, Czech Republic

**Abstract** Six earthworm species, *Allolobophora eiseni*, *Dendrobaena hortensis*, *D. veneta*, *Eisenia spelaea*, *Lumbricus melitae* and *Octolasion tyrtareum*, are newly recorded from the Czech Republic. The short descriptions of these species are given together with the data on their distribution and ecology. The list of species so far registered for the earthworm fauna of the Czech Republic is also included.

### INTRODUCTION

On the territory of former Czechoslovakia, faunistic research on the family Lumbricidae dates from the end of the last century (Vejdovský 1874, 1883). Since that time, more than one hundred papers reporting earthworms from that country has been published. However, modern investigations have been carried out predominantly in Slovakia (Zajonc 1981), whereas large areas in Bohemia and Moravia (Czech Republic) remain unexplored up to now. The present paper attempts to add to our knowledge of earthworm distribution in those areas.

### MATERIAL AND METHODS

In the Czech Republic, more than three hundreds localities were sampled for earthworms during the course of 1982-1993, from which the material containing 11582 specimens was obtained. Qualitative as well as quantitative sampling methods were used. Qualitatively, earthworms were collected in various structural parts of the biotopes (under stones, in soil, in moss, in plant remains, in decaying wood, under bark, etc.) to obtain species exhibiting various associations with the environment. Quantitative samples were collected by a combination of hand sorting after digging in the surface layer of the soil, chemical extraction technique of applying a 0.5% solution of formalin and/or heat extraction of soil samples in modified Meyer's apparatus (Meyer 1980). The lumbricids obtained were fixed in 4% formalin and stored in 7% solution of the same fixative. Reference specimens are deposited in the author's collection at the Institute of Soil Biology, České Budějovice.

Code numbers given in parentheses behind the names of localities indicate respective quadrangles on the faunistic map of Czechoslovakia (see Buchar 1982). Where is no other indication, there applies leg. V. Pižl.

### RESULTS

#### *Allolobophora eiseni* (Levinsen, 1884) (Fig. 1a)

**LOCALITIES.** Bohemia bor., Děčín (5151), 29.5.1982, 4 ex., Bohemia mer., Půlkovec (6852), 20.5.1985, 1 ex., Bohemia mer., Hluboká n. Vlt. (6952), 28.5.1985, 1 ex., Bohemia bor., Krkonoše Mts., V bažinkách (5259), 15.6.1988, 4 ex., 26.6.1990, 7 ex., Moravia bor.-or., Beskydy Mts., Mazácký Gruník (6476), 23.6.1987, 2 ex.

**DESCRIPTION.** Length 30-64 mm, diameter 2-5 mm, segment number 90-115. Body cylindrical. Colour purplish to brownish red, more yellowish below; pigmented. Prostomium tanylobous. First dorsal pore in furrow 5/6. Spermathecal pores absent. Male pores on conspicuous tumescences confined to 15, 1/3 of the distance from seta b to c. Clitellum on 24-32 (33), saddle-shaped, reaching down to within setal lines ab or aa. Tubercula pubertatis absent. Setae closely paired, post-clitellar formula aa:ab:bc:cd:dd = 5 : 1.2 : 5 : 1 : 10. Genital tumescences sometimes present around setae ab on segments 16, 17 and 25.

Septa 6/7-8/9 only slightly thickened. Seminal vesicles two pairs in 11,12, rudimentary. Spermathecae absent.

**DISTRIBUTION.** Cosmopolite. In Europe widespread westwards from Poland, Slovakia and Bulgaria. New species for the Czech Republic.

**ECOLOGY.** Epigeic, acidophilous and acidotolerant species, occurring under bark of fallen trees, under moss and decaying leaves. Often the dominant species in moorland, bog soils and by streams, pH 3.6-7.6. All my records are derived from the litter layer of deciduous forest soils.

*Dendrobaena hortensis* (Michaelsen, 1890) (Fig. 1b)

**LOCALITIES.** Bohemia centr., Prague (5952), 24.5.1982, 3 ex., Bohemia bor., Krkonoše Mts., Vrchlabí (5359), 20.7.1982, 39 ex., leg. J. Chalupský

**DESCRIPTION.** Length 15-50 mm, diameter 1.5-4.5 mm, segment number 42-130. Body cylindrical with the posterior region somewhat rhomboid and depressed. Colour redish purple dorsally, with a colourless papilla-like area round setae cd on segment 11 (or 11-12). Pigmentation extends ventrally over the first 14-15 segments and often in the caudal region, otherwise whitish yellow below. Prostomium epi- to tanylobous. First dorsal pore in intersegmental furrow 5/6. Spermathecal pores paired in 9/10 and 10/11, located near the mid-dorsal line. Male pores on segment 15 with small tumescences confined by the furrows 14/15 and 15/16. Clitellum on segments (26) 27-33, saddle shaped reaching down nearly to setal line b. Tubercula pubertatis form elliptical bands or ridges over segments 30, 31, intersegmental furrow 30/31 often not obliterated. Setae widely paired, post-clitellar formula 1.5 : 1 : 1.5 : 1 : 3. Genital tumescences surround setae ab on segments (9,10) 11, 12 and in the clitellar region, but often lacking.

Septa 13/14, 14/15 strongly muscular, those 7/8 - 9/10 somewhat thickened. Seminal vesicles paired usually in segments 9-12 but either or both of the anterior pairs may be rudimentary or fail to develop. Two pairs of spermathecae in segments 9, 10.

**DISTRIBUTION.** Cosmopolitan species. In Europe from Turkey, Greece, Albania, Macedonia, Italy, France to Portugal. Introduced into England, Switzerland, Germany, Hungary and Slovakia. New species for the Czech Republic.

**ECOLOGY.** Epigeic species, living in decaying forest litter. Now the species is widespread in organic rich soils of greenhouses, gardens and pastures. Both our records come from compost heaps in gardens.

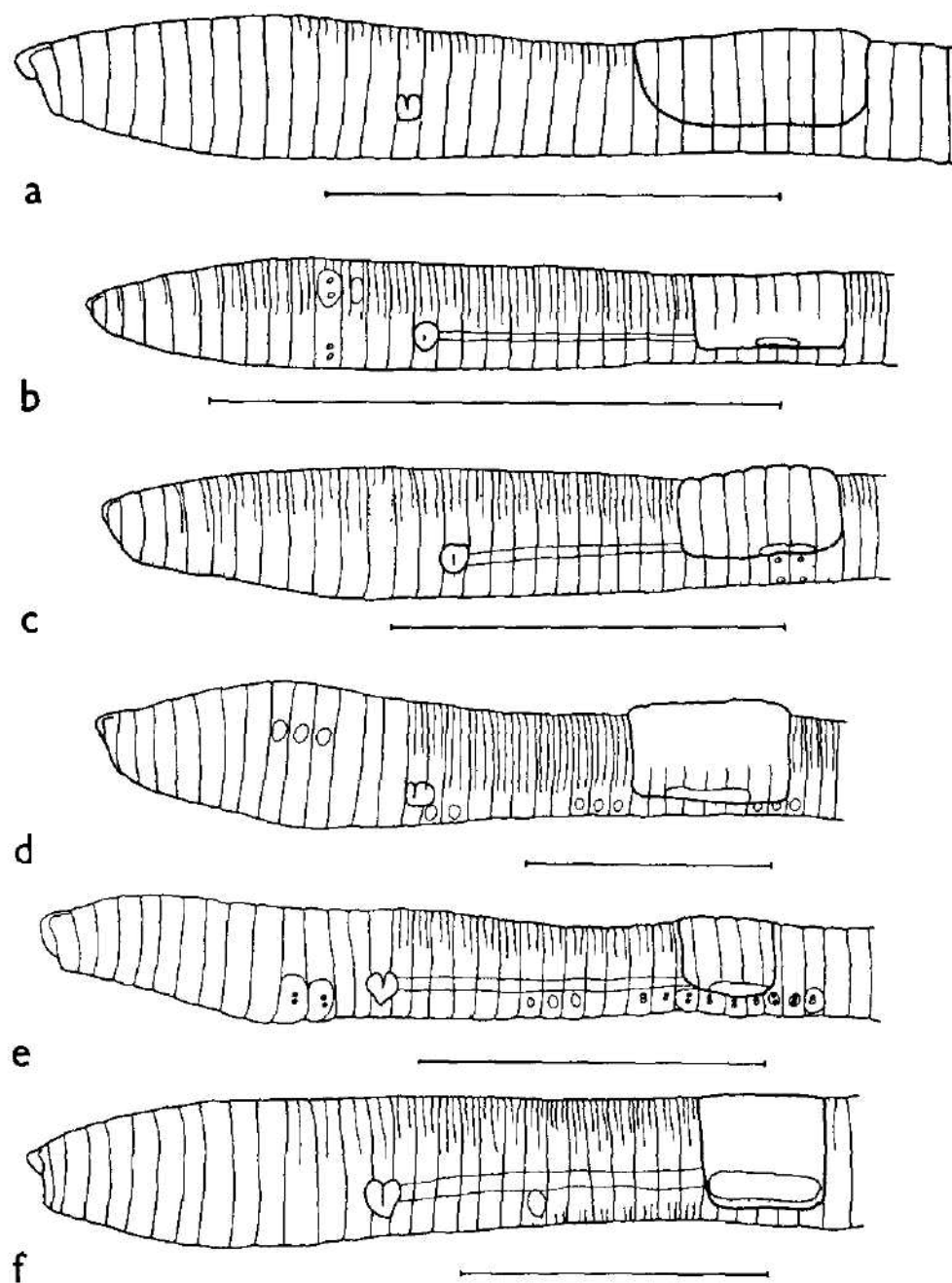


Fig 1 a - *Allotobophora eiseni*, b - *Dendrobaena hortensis*, c - *Dendrobaena veneta*, d - *Eisenia spelaea*, e - *Lumbricus meliboeus*, f - *Octolasion tyrtareum*. Scale = 1 cm.

*Dendrobaena veneta* (Rosa, 1886) (Fig. 1c)

LOCALITIES. Bohemia centr., Prague (5952), 29.4.1982, 2 ex., 24.5.1982, 26 ex., Moravia mer., Brno (6865), 26.4.1988, 5 ex., leg. Houšková

DESCRIPTION. Length 21-155, diameter 2-8 mm, segment number 65-255. Body cylindrical, posterior region tending to become rectangular in transverse section, slightly depressed. Colour, a conspicuous reddish purple mid-dorsal stripe with intrasegmental bands mainly incomplete ventrally, intersegmental furrows and most of the ventral surface unpigmented flesh colour to whitish yellow. Prostomium variable from epilobous to tanylobous. First dorsal pore in furrow 5/6. Spermathecal pores in furrows 9/10, 10/11 located near the mid-dorsal line. Male pores with large tumescences confined to segment 15. Clitellum over segments (25,26) 27-32 (33), saddle-shaped. Tubercula pubertatis on (29) 30-31 (32), usually ridge-like but the furrows are seldom completely obliterated, occasionally papillate and nearly circular on segments 30 and 31 only. Setae widely paired, post-clitellar formula 1.5 : 1 : 1.5 : 1 : 3. Genital tumescences usually surround setae ab in the clitellar region, at least on segments 30 and 31, cd on 12.

Most of the anterior septa thickened: 5/6-12/13 slightly muscular, 13/14, 14/15 strongly muscular. Seminal vesicles in four segments, 9-12. Spermathecae two pairs in 9 and 10.

DISTRIBUTION. Transcaucasia westwards through Turkey, Carpatho-Balkan Peninsula, Croatia, Slovenia and Italy into Spain. Found also in Poland, Slovakia, Ireland, England, Wales and California. New species for the Czech Republic.

ECOLOGY. Epigeic species, occurring under decaying leaves and in the top layer of organic rich soils; commonly recorded from compost heaps, manure and sewage beds. Our records are derived from compost heaps in gardens.

*Eisenia spelaea* (Rosa, 1909) (Fig. 1d)

LOCALITIES. Bohemia mer., Pukatec (6852), 20.5.1985, 9 ex., Bohemia mer., Hluboká n. Vlt. (6952), 28.5.1985, 18 ex.

DESCRIPTION. Length 70-98 mm, diameter 6-7 mm, segment number 84-95. Body cylindrical, slightly flattened posteriorly. Colour redish-purple, with pigmentless yellow intersegmental furrows. Segments 9-11 pigmentless laterally. Prostomium epilobous, open. First dorsal pore in furrow 4/5. Spermathecal pores paired in furrows 9/10, 10/11, opening slightly above setal line c. Setae closely paired, post-clitellar formula. Male pores on 15, surrounded by large tumescences encroaching onto segment 16. Setae closely paired, genital tumescences present around setae ab on segments 16, 17, 23-25, 32, 33, 34, and around cd on 9, 10 and 11. Clitellum occupies segments 26-33, saddle shaped. Tubercula pubertatis on 28-31.

Septa 12/13 and 13/14 thickened. Seminal vesicles four pairs, in 9-12. Spermathecae two pairs in 9 and 10.

DISTRIBUTION. *E. spelaea* was recorded from Alpine (Italy, Hungary, Slovenia, Croatia) and Carpathian (Ukraine, Roumania, Slovakia) regions. New species for the Czech Republic.

ECOLOGY. Epi-hypogaeic species, which occurs in root-layer of moist soils in woodland, known also from caves. My material was collected in wet depressions of deciduous and spruce forests.

*Lumbricus meliboeus* Rosa, 1884 (Fig. 1e)

LOCALITIES. Bohemia mer., Purkarec (6852), 20.5.1985, 14 ex., Bohemia mer., Hluboká n. Vlt. (6952), 28.5.1985, 18 ex.

DESCRIPTION. Length 57-84 mm, diameter 3-5 mm, number of segments 56-104. Body cylindrical, behind clitellum slightly dorsoventrally flattened. Colour red-violet and iridescent, with dorso-ventral and antero-posterior gradient. Prostomium tanylobous. Dorsal pores good visible, first in 6/7. Two pairs of spermathecal pores in line of b, at 9/10 and 10/11. Male pores on 15, with elevated glandular papillae sometimes extending to 14 and 16. Clitellum saddle-shaped, on (29) 1/2 29 - 1/y 33 (33). Tubercula pubertatis band-like, on (1/3 30) 1/2 30-32 (1/n 33). Setae closely paired, post-clitellar formula 7:1:8:1:25. Setae ab of segments 11, 12 and 22-32, 35 on genital tumescences.

Septa begin in 4/5, 7/8 and 9/10 somewhat thickened, then thin and membranous posteriorly. Three pairs of seminal vesicles in 9, 11, 12. Two pairs of spermathecae in 9 and 10.

DISTRIBUTION. *Lumbricus meliboeus* has been previously recorded from the Alpine region of Italy, Switzerland, Germany, Austria, France and Slovenia. One specimen reported by Piquet (1919) from Sarek region in northern Sweden should also be mentioned here, permitting to consider about boreo-alpine distribution of the species. However, this record has never been confirmed, and I agree with the opinion of Stöp-Bowitz (1969) who stated it as doubtful. New species for the Czech Republic.

ECOLOGY. Little seems to be known about the habitat and biology of this species. According Zicsi (1965) and Wilcke (1967) it lives in litter of deciduous forests; Bouché (1972) reports that *L. meliboeus* occurs exclusively in mountains, and is hygrophilous, relative acidotolerant and stenotomic. Morphological and ecological features indicate that the species belongs to intermediate form between epigeic group of earthworms and the anecic one. My records are derived from A-horizon of damp soil in depressions of mixed deciduous forest.

*Octolasion tyrtareum* (Savigny, 1826) (Fig. 1f)

LOCALITIES. Bohemia bor.-occ., Sokolov (5841), 18.5.1993, 5 ex., Bohemia mer., Šumava Mts., Boubín (7048), 6.10.1993, 4 ex.

DESCRIPTION. Length 25-160 mm, diameter 2.5-6 mm, segment number 87-135. Body cylindrical, slightly octagonal posteriorly. Colour whitish grey to blue, rarely rosy pink or brownish; unpigmented. Prostomium epilobous. First dorsal pore in or behind furrow 8/9, mostly between 10/11 and 12/13. Spermathecal pores paired in furrows 9/10, 10/11, opening slightly above setal line c. Male pores paired on segment 15 above line b, with large tumescences obliterating parts of furrows 14/15 and 15/16 and encroaching onto the adjacent segments. Clitellum extends over

30-35, saddle shaped reaching down to within setal line ab. Tubercula pubertatis form longitudinal bands within the ventral border of the clitellum throughout its entire length, i.e. 30-35. Setae closely paired anteriorly, becoming widely paired to distant more posteriorly, immediate post-clitellar formula 3 3 · 1.6 · 1.3 · 1 · 7.3. Genital tumescences surround setae ab and often cd on segments (9) 10 (11) 12 and also setae s on (21) 22 (23).

Septa 6/7-14/15 muscular. Seminal vesicles in 9-12, the two posterior pairs being larger than the two anterior ones. Spermathecae two pairs in 10 and 11.

**DISTRIBUTION.** *Octolasion tytiareum* seems to occur in southern and western Europe, the Middle East and most of North America with introduced populations in South Africa, India, Australia and Oceania. However, records of this species have been often confused with those of *O. lacteum* (Savigny, 1826). New species for the Czech Republic.

**ECOLOGY** Hypogeic, neutrophilous and acidophilous species. It lives in various biotopes, from pastures, arable land and gardens to forests, where is often found under stones and logs, in decaying leaves, compost, peat; in soils of pH 4.3-8.1. It seems to be more hygrophilous than *O. lacteum*, being more abundant in moist soils of bogs, caves and stream banks.

#### CONCLUSIONS

Faunistic research of earthworms resulted in additional six species of lumbricids being newly recorded from the Czech Republic. Together with the records presented here, the list of the Czech earthworms fauna contains the following taxa:

- 1 *Allolobophora chlorotica chlorotica* (Savigny, 1826)
- 2 *Allolobophora eiseni* (Levinsen, 1884)
- 3 *Allolobophora hrabei* (Černosvitov, 1935)
- 4 *Allolobophora moravica* (Pižl et Houšková, 1994)
- 5 *Allolobophora parva* Eisen, 1874
- 6 *Aporrectodea caliginosa caliginosa* (Savigny, 1826)
- 7 *Aporrectodea caliginosa trapezoides* (Dugés, 1828)
- 8 *Aporrectodea georgii* (Michaelsen, 1890)
- 9 *Aporrectodea handlirschi handlirschi* (Rosa, 1897)
- 10 *Aporrectodea icterica icterica* (Savigny, 1826)
- 11 *Aporrectodea longa longa* (Ude, 1885)
- 12 *Aporrectodea rosea rosea* (Savigny, 1826)
- 13 *Dendrobaena attemsi attemsi* (Michaelsen, 1902)
- 14 *Dendrobaena hortensis* (Michaelsen, 1890)
- 15 *Dendrobaena illyrica* (Cognetti, 1906)
- 16 *Dendrobaena mrazeki* (Černosvitov, 1935)
- 17 *Dendrobaena octaedra* (Savigny, 1826)
- 18 *Dendrobaena vejvodskyi* (Černosvitov, 1935)
- 19 *Dendrobaena veneta veneta* (Rosa, 1886)
- 20 *Dendrodrilus rubidus rubidus* (Savigny, 1826)
- 21 *Dendrodrilus rubidus subrubicundus* (Eisen, 1874)
- 22 *Dendrodrilus rubidus tenuis* (Eisen, 1874)
- 23 *Eisenia fetida fetida* (Savigny, 1826)
- 24 *Eisenia spelaea spelaea* (Rosa, 1901)
- 25 *Eisenia submontana* (Vejdovský, 1875)
- 26 *Eiseniella tetraedra tetraedra* (Savigny, 1826)

- 27 *Eiseniella tetraedra intermedia* (Černosvitov, 1934)
- 28 *Eiseniella tetraedra pupa* (Eisen, 1874)
- 29 *Fitzingeria platyura platyura* (Fitzinger, 1833)
- 30 *Fitzingeria platyura depressa* (Rosa, 1893)
- 31 *Fitzingeria platyura montana* (Černosvitov, 1932)
- 32 *Helodrilus antipae antipae* (Michaelsen, 1891)
- 33 *Helodrilus antipae tuberculatus* (Černosvitov, 1935)
- 34 *Helodrilus oculatus oculatus* Hofmeister, 1845
- 35 *Kistodrilus auriculatus* (Rosa, 1897)
- 36 *Lumbricus baicalensis* Michaelsen, 1900
- 37 *Lumbricus castaneus* (Savigny, 1826)
- 38 *Lumbricus meliboeus* Rosa, 1884
- 39 *Lumbricus polyphemus* (Fitzinger, 1833)
- 40 *Lumbricus rubellus rubellus* Hofmeister, 1843
- 41 *Lumbricus terrestris* Linnaeus, 1758
- 42 *Octodrilus argovienensis* (Bretsch, 1899)
- 43 *Octodrilus complanatus* (Duges, 1828)
- 44 *Octodrilus transpadanus* (Rosa, 1884)
- 45 *Octolasion cyaneum* (Savigny, 1826)
- 46 *Octolasion lacteum* (Savigny, 1826)
- 47 *Octolasion montanum* (Wessely, 1905)
- 48 *Octolasion tyriarum* (Savigny, 1826)

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## BOOK REVIEW

PETERS W. *Colour Atlas of Arthropods in Clinical Medicine*. London: Wolfe Publishing, 1992, 304 pp, 190 x 260 mm. Price hardcover Lstg 90 00. ISBN 0-7234-1653-2.

As emphasized in the introduction, up to now no single work has brought the whole gamut of the arthropods, including the insects, together with diseases, parasitoses, and envenomations for which they are responsible, in the pictorial form such as that in the "Colour Atlases" in this series. The phylum Arthropoda, defined as joint-limbed animals protected by an exoskeleton, contains the largest number of species of any phylum in the animal kingdom. Many of them are of considerable importance to human and veterinary medicine because they act as hosts in the transmission cycles of some of the most troublesome and, in many cases, lethal diseases that affect man and animals. In the course of this evolution, man has greatly influenced the geographical distribution of many arthropod species. The disastrous disruption of human society and the environment by war and famine has always been associated with surges of arthropod-borne and other diseases. Global warming through the so-called "greenhouse effect" brings with it the positive danger that a number of major vector-borne diseases will extend beyond their present geographical limits. Many arthropods cause various degrees of discomfort, if not pathological changes.

This book consists of five parts containing 19 sections or chapters in all. Each part characterizes a particular group of arthropods and diseases associated with them. It includes a general textual part and figures complemented with descriptive legends. A total number of figures is 990. They constitute colour photographs of organisms and pathomorphological changes in organs and tissues caused by them, terrestrial biomes and ecological aspects, technological procedures and appropriate equipment, stereoscans, schematic drawings and diagrams, life cycles, and charts of geographical distribution of diseases. In the acknowledgements numerous authors from all parts of the world are listed who gave the assistance in providing pictures and their personal expertise. Acknowledgement is made also to various scientific organizations. In addition, there are 32 tabular reviews summarizing information and classification schemes of the phylum Arthropoda, arthropod vectors of diseases, arboviruses and other arthropod-borne agents, and particular groups of arthropods of medical importance.

Part 1 focuses on the zoology of the arthropods with particular reference to evolution, classification, physiology, and life cycles.

Part 2 is the most extensive (112 pages). It deals with arthropods as disease vectors. Following chapters are covered here: arboviruses, rickettsioses, bacterial infections, malaria, babesiosis and theileriosis, trypanosomiasis, leishmaniasis, and helminthiasis. Arboviruses include such important pathogens as those causing yellow fever, dengue, Japanese B encephalitis, and Rift Valley fever. There is an overview of hard and soft ticks, their main hosts, distribution, and associated diseases or pathogens. Further on classification and causes of haemorrhagic fevers, mosquitoes implicated in the transmission of arboviruses, rickettsial diseases transmitted by ticks, mites and lice, and other infections caused by bacteria, viruses and protozoa are discussed here. The section on malaria provides insights into the morphology of anopheline mosquitoes, life cycle of malarial plasmodia, methods of anopheline mosquitoes surveys, malaria vector species in subgenera *Anopheles*, *Cellia*, *Nyssorhynchus* and *Kerteszia* in the Old and New Worlds, and methods for malaria control. Following sections are devoted to babesiosis and theileriosis and to trypanosomiasis in South America and Africa with classification of tsetse flies, with reservoirs and control measures. The section on leishmaniasis gives comprehensive overviews of sandfly vectors and *Leishmania* species in the Old and New Worlds followed by figures demonstrating life cycles, epidemiological and clinical aspects. Arthropod-borne helminthiasis cover wide variety of infections with trematodes, cestodes and nematodes, in the life of which arthropods play an essential role as intermediate hosts. There is a concise overview of crustacean intermediate hosts of lung flukes that affect man. In last years additional about 11 *Parago-*

(to be continued on p. 216)

**A new species of *Anthaxia* from Cyprus (Coleoptera: Buprestidae)**

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**Taxonomy, *Anthaxia aureoviridis* sp. n., Coleoptera, Buprestidae, Cyprus**

**Abstract** *Anthaxia* (s. str.) *aureoviridis* sp. n. (*A. fulgurans* species group) is described, illustrated and compared with *A. fulgurans* (Schrank, 1789)

*Anthaxia* (s. str.) *aureoviridis* sp. n. (Figs 1, 3)

**DESCRIPTION.** Rather small, flattened, slightly lustrous species with well developed sexual dichromatism: head, pronotum and ventral side of body golden green, pronotum with two large black spots, elytra dark golden, golden-green or brown-green with indistinctly separate blue-green postscutellar stripe, reaching nearly three fifth of elytral length (male), or head and pronotum black, clypeus, pronotal margins and central part of pronotum with blue lustre, elytra brick-red with golden green or blue-green postscutellar stripe, ventral side of body black with green lustre (female); elytra and ventral side of body with microscopic white pubescence.

Head small, clypeus slightly incurved anteriorly, frons with wide and deep longitudinal depression, vertex about 1.7 times as wide as width of eye; sculpture of head very indistinct, consisting of polygonal cells without central grains which are almost covered by microsculpture (mainly in female); eyes small, not projecting beyond outline of head; antennae short, black with metallic lustre in both sexes, the third antennal segment short, only slightly longer than the second or the fourth, segments 5 - 10 triangular, about as long as wide, the 11th segment shortly elliptical.

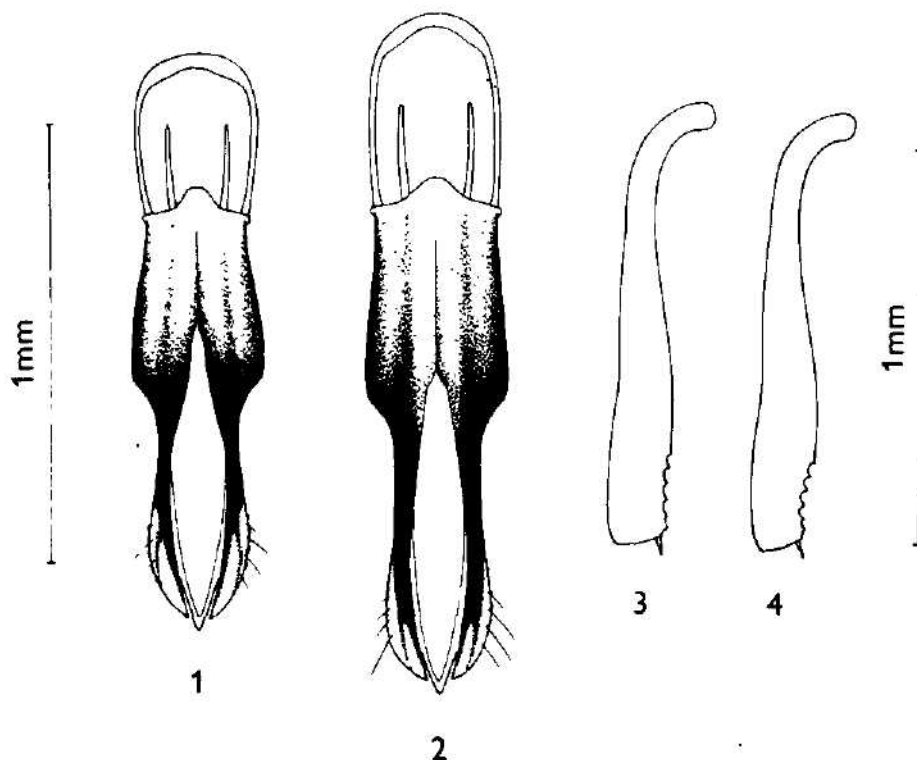
Pronotum wide, 1.8 times wider than long, slightly vaulted, with large and deep laterobasal depressions; anterior pronotal margin slightly lobate medially, posterior margin almost straight, lateral pronotal margins regularly rounded and incurved before posterior angles; maximum pronotal width in middle; sculpture of laterobasal pronotal depressions consisting of very prolonged cells, forming typical longitudinal keels along pronotal margins, central part of pronotum with rounded and polygonal cells anteriorly and with several irregular transverse wrinkles in posterior part; whole pronotum with basal microsculpture, central part sharply punctured anteriorly.

Scutellum pentagonal, somewhat wider than long, black with golden green lustre (male) or black (female).

Elytra subparallel, 1.5 - 1.6 times as long as wide at humeral part; humeral swellings and basal transverse elytral depressions well developed; elytral epipleurae narrow, not reaching apex of elytra; elytral lateral margins widely rounded in apical third and straight before apex, each elytron rounded separately; apical margins of elytra with extremely fine, almost indistinct lateral serration; elytral structure grainy, very homogenous, with fine basal microsculpture and with feeble, short irregular longitudinal and transverse wrinkles; apex of elytra with distinct, large

and deep punctures; elytra somewhat less lustrous than pronotum.

Ventral side of body with fine basal microsculpture, almost matt, reticulate structure more distinct only on basal abdominal sternites; anal sternite simply rounded in both sexes, lateral serration almost indistinct; male mesotrochanters with sharp, metatrochanters with somewhat shorter and blunt spine.



Figs 1-4. 1 - aedeagus of *Anthaxia aureoviridis* sp. n. (holotype); 2 - the same, *A. fulgurans*; male metatibia of *A. aureoviridis* sp. n. (holotype); 4 - the same, *A. fulgurans*.

Legs rather short, male metatibiae with shallow inner preapical incurvation or almost straight (Fig. 3), meso- and metatibiae of female not modified.

Aedeagus short, parameres distinctly enlarged in basal part and shortly narrowed before middle, apex of parameres widely, regularly rounded (Fig. 1).

Length 3.8 - 4.9 mm (holotype 4.9 mm), width 1.6 - 2.0 mm (holotype 2.0 mm).

TYPE MATERIAL. Holotype - male: Cyprus, Kykkou, 5.-7.vi.1993, M. Kafka leg. Allotype - female: the same data. Paratypes - 17 males and 4 females: the same data (4 males and 1 female); Cyprus, Saittas, 31.v.-3.vi.1993, M. Kafka leg. (1 male and 1 female); Cyprus, Kykkou, 5.-7.vi.1993, M. Krajčák leg. (9 males and 1 female); Cyprus, Saittas, 31.v.-3.vi.1993, M. Krajčák leg. (3 males and 1 female). Holotype and allotype in the collection of author. Paratypes in the collection of Ing M. Kafka, Dr M. Krajčák and author.

HOST PLANT. Unknown.

DIFFERENTIAL DIAGNOSIS. *Anthaxia aureoviridis* sp. n. (*A. fulgurans* species group) belongs by colouration of male antennae and sculpture of elytral apex to *A. fulgurans* species complex sensu Bflý (1984). This new species with well developed sexual dichromatism (undeveloped in *A. nigricollis* Abeille, 1904, slightly developed in *A. muliebris* Obenberger, 1918 - Obenberger 1938) differs from *A. fulgurans* (Schrank, 1789) by fine, homogenous and less lustrous structure of elytra, by form of male metatibiae (Figs 3, 4), indistinct sculpture of frons, by form of aedeagus (Figs 1, 2) and by brick-red elytral colouration of female.

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*nimus* species have been described as parasites of man in parts of Far East, in West Africa and Latin America. Further on arthropod vectors of dracunculiasis, lymphatic filariasis, onchocerciasis and loiasis, thelaziasis and some rare zoonotic infections are figured here.

Part 3 comprises arthropods as ectoparasites. Discussed here are acarnines of medical importance that can give rise to generalized or systemic and cutaneous allergic reactions. Insects are represented by hemipterans (genus *Cimex*), sucking lice and flies.

Part 4 concentrates on arthropods as endoparasites in humans. Recorded in this part are zoonotic infections with pentastomids. *Proteocephalus crotali* parasitizes some snakes, and linguatulid species can cause the syndrome "halzoun" or "marrara" or lesions in internal organs (liver, lungs, eyes). In following chapters included are scabies and demodex infections, myiasis with five families/subfamilies and 16 genera of myiasis producing dipterans, and finally tungiasis that caused by the tropical chigger or jigger flea *Tunga penetrans*.

Part 5 is concerned with harmful and venomous arthropods. Scorpions of medical importance belong to the Buthoidea and Chactioidea superfamilies with some 45 genera or species from the Mediterranean region, from Africa, North and South America, from Asia and Australia. In following chapters the whip scorpions and pseudoscorpions are mentioned. Spiders harmful to man include six suborders. Clinical aspects with systemic reactions and necrotic lesions of araneidism/loxoscelism/latrodectism are figured here. Crustaceans contain a diverse collection of arthropods. In addition to their importance as intermediate hosts, a number of crabs have been implicated as the cause of poisoning through consumption by man. About 46 tropical or subtropical crustacean species from four classes/subclasses are known or suspected to be toxic to man. In following sections figured are diplopods, chilopods, and insects (Hemiptera, Lepidoptera, Diptera, Hymenoptera, Coleoptera) capable to produce damaging bites or dangerous envenomations. In conclusion, a bibliography offers a comprehensive list of references to the primary literature.

This publication is closely related to "A colour atlas of Tropical Medicine & Parasitology", third edition 1989 by W. Peters and H. M. Gilles. It is a vital illustrated guide to a wide range of readers, students, physicians from general practitioners to tropical specialists, and medical entomologists. Its pictorial form impressive concerning variety of colours and bizarreness of animals harmful to human health. Some clinical aspects figured here are literally dramatic. This colour atlas presents an essential complement to classical textbooks of tropical medicine, medical zoology and parasitology, in particular entomology.

Jindřich Jirů

(continuation from p. 212)

Comment on the supraspecific taxon *Tergosmia* and redescription  
of *Osmia agilis* (Hymenoptera: Apoidea: Megachilidae)

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Taxonomy, redescription, *Osmia agilis*, *Tergosmia*, Megachilidae, Hymenoptera, Palearctic region

**Abstract.** The position and status of *Tergosmia* Warncke, 1988 within the tribe Osmiini is discussed and a detailed redescription of *Osmia agilis* Morawitz, 1875 is given.

The peculiarities of *Tergosmia* Warncke

The position of *Tergosmia* that was established by Warncke, 1988 originally as a subgenus of *Osmia* appears - due to the unusual combination of certain structural characters - unquestionably uncertain if not somewhat ambiguous. In the case that all the supraspecific taxa described as yet within Osmiini are considered as subgenera of a single large genus *Osmia*, *Tergosmia* is revealed as an intermediate taxon between the *Osmia*-like and the *Anthocopa*-like subgenera complexes. Nevertheless if within Osmiini a certain number of these supraspecific taxa are virtually recognized as distinct genera (each of them with a number of respective subgenera) the position of *Tergosmia* remains doubtful. While several but not insignificant characters (i.e. the lack of a stria on the ventrolateral portion of tergite 1, the shape of apical margin of the female clypeus, the short and basally widened uncus of fore and middle tibiae of the females, and the shape of apical margin of the male tergite 7) recall markedly the genus *Anthocopa*, some others (as the distinctly punctiform notalices in both sexes, in the male sex the rounded lateral portion of the apical margin of the tergite 6 without any suggestion of sharply pointed teeth so well pronounced in *Anthocopa*-like subgenera, the lack of a paired membrane of the gradulus of the sternite 6, and the only four exposed sternites) correspond on the contrary well with the large complex of subgenera allied to *Osmia* s. str.

If the point of view to split up the large genus *Osmia* into several distinct genera is a right and warranted trend in the present classification it seems best to raise *Tergosmia* to the generic level (including the meanwhile monotypic subgenus *Heterosmia* recently separated from *Tergosmia* by Tkalců, 1993) because of its evidently intermediate character; it clearly deviates both from *Osmia* and from *Anthocopa* and cannot be simply associate with any of them, unless the global conception of both these genera is considerably altered.

*Tergosmia agilis* Morawitz, comb. n.

*Osmia agilis* Morawitz, 1875: 88-89, female, male.

After being briefly described in Latin and more extensively so in Russian language from five

various localities of Middle Asia only little can be found in the literature in regard to this apparently rare, locally distributed and hence poorly known species. Ducke (1900) recapitulating the Latin part of the original description and adding the faunistic record published by Morawitz (1880) obviously did not know it from his own experience and put it - perhaps only due to the integumental colour given by Morawitz (l. c.) as "aeneo-submicans" (p. 17) - to the *Osmia versicolor*-group of the subgenus *Chalcosmia*. Friese (1911) followed Ducke (1900) and presented only a very short and insufficient diagnosis in German. Popov (1967: 70) likewise mentioned the species as a member of the subgenus *Chalcosmia* and added one new faunistic record. Recently Zanden (1988: 123) put *Osmia agilis* to the subgenus *Caerulosmia*, established by himself. The same author (Zanden 1991) published supplementary notes to the original description (p. 49) in addition to the designation of the lectotype (p. 48) and presented (p. 71) four sketches of structural details, i.e. the apical margin of the female clypeus in two different views, the apical margin of the male clypeus and the apical margin of the male tergites 6 and 7. Although Warncke (1988) did not include *O. agilis* in his established subgenus *Tergosmia*, there is no doubt this is where it really belongs as subsequently the same author (Warncke 1992) confirmed.

#### REDESCRIPTION

**FEMALE MORPHOLOGY** Inner orbits in their lower two thirds converging below. Mandibles tridentate. Mouth parts of moderate length. Maxillary palpi 5-segmented. Sides of galeae with sparse erect hooked yellow bristles, longest basally and gradually becoming short toward apex. Upper margin of lateral ocelli situated distinctly above supraorbital line. Ocelloocular distance 512  $\mu$ m, ocellooccipital distance 288  $\mu$ m. Clypeus (like in other *Tergosmia*-species) markedly protuberant (Fig. 1), its lateral margins rather long, apical margin narrow, straight, overhanging base of labrum, polished and slightly impressed transversely, surface of clypeus uniformly covered by dense punctures (30  $\mu$ m) with interspaces mostly edgily narrow and polished. Frontoververtex, mesoscutum and scutellum with punctation but slightly coarser (35  $\mu$ m), less uniformly arranged and less crowded; polished interspaces here and there wider, on frontoververtex intermixed with scattered minute punctures (10  $\mu$ m) in some places. Size of punctures of genal area similar to that of clypeus. Proximal segments of flagellum as in Fig. 2. Tegulae polished and bare except for fine punctation (10  $\mu$ m) of their anterior parts and along outer margins. Propodeal triangle dull throughout with a wide, coarsely roughened basal transverse zone, remaining lower portion obscurely reticulate. Adjacent parts of propodeum equally dull, with shallow, ill defined fine punctures and chagreened interspaces. Uncus of protibia very short and wide, without a sharp pointed spine [obviously a valid supraspecific character, not mentioned by Warncke (1988)]. Strigilis as in Fig. 3. Hind coxae with a sharp ventral carina. Tergite 1 with well developed gradulus, disappearing laterally; its basal concave portion midapically extensively bare, polished except for shallow reticulation along median longitudinal sulcus. Median part of dorsal surface of tergite 1 moderately densely punctured, punctures round and of rather uniform size (25  $\mu$ m), interspaces of 1 to 2 puncture width, polished; lateral parts generally more densely punctate with rather narrow interspaces. Ventrolateral portion of tergite 1 without stria. Tergite 2 anterior to gradulus dull, sharply chagreened throughout, with a few scattered indistinct fine punctures (15  $\mu$ m). Punctation of exposed surfaces of tergites 2-5 similar to that of dorsal part of tergite 1, only on tergite 5 slightly denser; a wide belt along apical margin of tergites 4 and 5 abruptly covered with dense confluent small punctures. Tergite 6 with dense and sharply delimited fine (15-20  $\mu$ m) punctures, separated by very narrow, obscurely shagreened but rather shining interspaces.

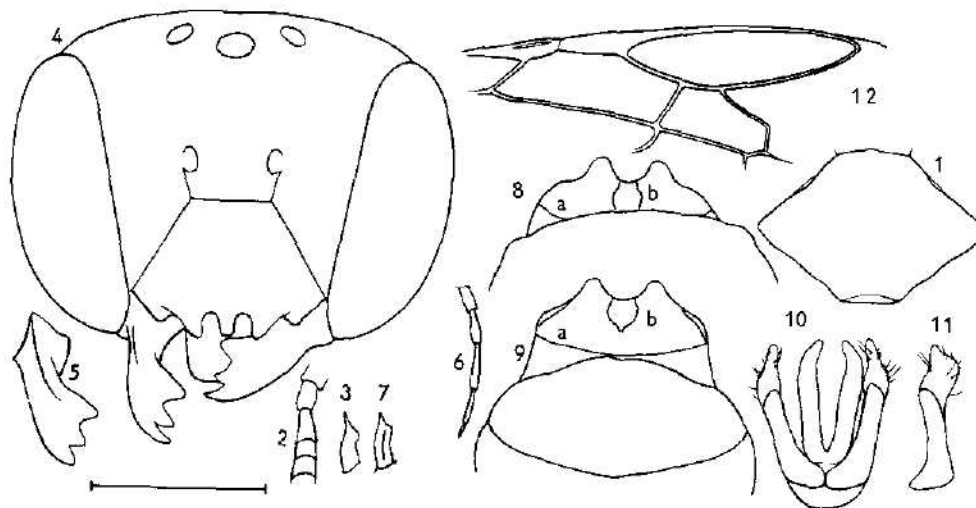
Body length ca. 6.5 mm [according to Morawitz (1875) 7 mm], length of fore wing 5 mm.

INTEGUMENT as indicated for the male sex below. Teeth of mandibles dull reddish-brown.



The colouring defined by Morawitz (1875) as "aeneo-submicans" appears very inconspicuous, recently defined by Zanden (1991: 49) as "Abdomen schwach erzfarbig".

**PUBESCENCE.** Colour similar to that of male. No tufts of bristles arising beneath anterior clypeal margin (a supraspecific character, common to all the *Tergosmia*-species hitherto known, but not mentioned by Warncke 1988). Fasciae of rather long white hairs on tergites 1-3 only laterally; tergites 4 and 5 each with entire band along apical margin, consisting of shorter recumbent white hairs. Scopa whitish.



Figs. 1-12. *Tergosmia agilis* (Morawitz). 1 - Clypeus, female with polished and slightly impressed apical area, 2 - three basal flagellar segments of right antenna, female, 3 - strigilis, female, 4 - head in frontal view, male, 5 - right mandibula, male, 6 - palpus maxillaris, male, 7 - strigilis, male, 8 - tergites 6 and 7 (a = gradulus, b = impunctate swollen and strongly polished area), 9 - same, tergites more exposed, 10 - genitalia, male, in dorsal view, 11 - same in dorso-lateral view, 12 - venation of fore wing, male. Scale for Fig. 6 = 0.5 mm, for others = 1 mm.

**MALE-MORPHOLOGY.** Inner orbits converging below for their whole length (Fig. 4). Mandibles tridentate (Fig. 5). Mouth parts as in female, but sides of galeae lacking any hooked hairs. Position of ocellar triangle similar to that of female. Ocelloocular distance 460  $\mu$ m, ocellooccipital distance 352  $\mu$ m. Clypeus with anterior margin markedly 3-lobed (Fig. 4), surface dull, with punctation very fine (15-20  $\mu$ m) and confluent (otherwise thickly covered with pubescence in fresh specimens) except for anterior lobes which are bare and strongly polished. Palpus maxillaris as in Fig. 6. Sculpture of head and thorax similar to that of female; roughened mediobasal portion of propodeal triangle less distinct. Strigilis as in Fig. 7. Hind coxae with only a feeble suggestion of a ventral carina. Sculpture of tergites also similar to the female. Tergites 2-6 each with distinct gradulus, pregradular portion sharply and uniformly shagreened; exposed dorsal parts of these tergites shining, only slightly more densely punctured than in female (tergite 6 but very densely so). Interspaces very narrow to a half puncture width. Tergites 4-6 with very fine punctation along apical margins (similar to that of these parts of tergites 4 and 5 in female sex). Configuration of tergites 6 and 7 as in Fig. 8 and 9; tergite 7 posterior to gradulus slightly

constricted transversely, in front of midapical emargination with an impunctate swollen and strongly polished area. Margin of sternite 1 moderately arcuate, with a feeble midapical emargination. Sternites 2 and 3 broadly arcuate. Sternite 4 with broad midapical margin straight. Sternite 5 with rather deep and greatly widened midapical emargination. Sternite 6 broadly rounded. Ground between punctures chagreened on sternites 1-5. Genitalia as in Figs. 10 and 11.

Body length ca. 6-7 mm.

INTEGUMENT. Black. Antennae black-brown. Tibial spurs whitish-yellow. Terminal segments of tarsi brownish-yellow, those of hind legs somewhat darker. Fore wing membrane nearly hyaline, venation brown to brownish-black. Genitalia with penis valvae ochreous, gonocoxites and gonostyli distinctly darker, yellowish-brown.

Pubescence. Rather long and uneven, dense on clypeus but not very dense on remaining parts of head and thorax, partly so on tergite 1, short on remaining tergites. Colour: pale whitish-yellow on head, pale brownish-yellow on thoracic dorsum. Tergites 2-6 with subapical fasciae of short recumbent whitish hairs. Sternites 1-3 with loose, rather long recumbent hairs along apical margins. Hairs of sternite 4 only short and inconspicuous. A large mediobasal portion of sternite 5 covered with dense short recumbent velvety pubescence; midapical emargination of sternite 5 with long dense recumbent pale yellow bristles. Sternite 6 having dense short recumbent velvety pubescence on mediobasal portion and short loose inconspicuous hairs on remaining part.

MATERIAL EXAMINED. Uzbekistan: Nuratau Mts. nr. Farish, 13.5. 1985, 2 males, R. Borovec lgt., coll. Tyrner Kara Tepe nr. Samarkand, 19.5. 1974, 1 female, K. Deneš lgt., coll. Pádr. - Turkmenistan: Kara-Kala, 1 female, S. Bečvář lgt., coll. Halada.

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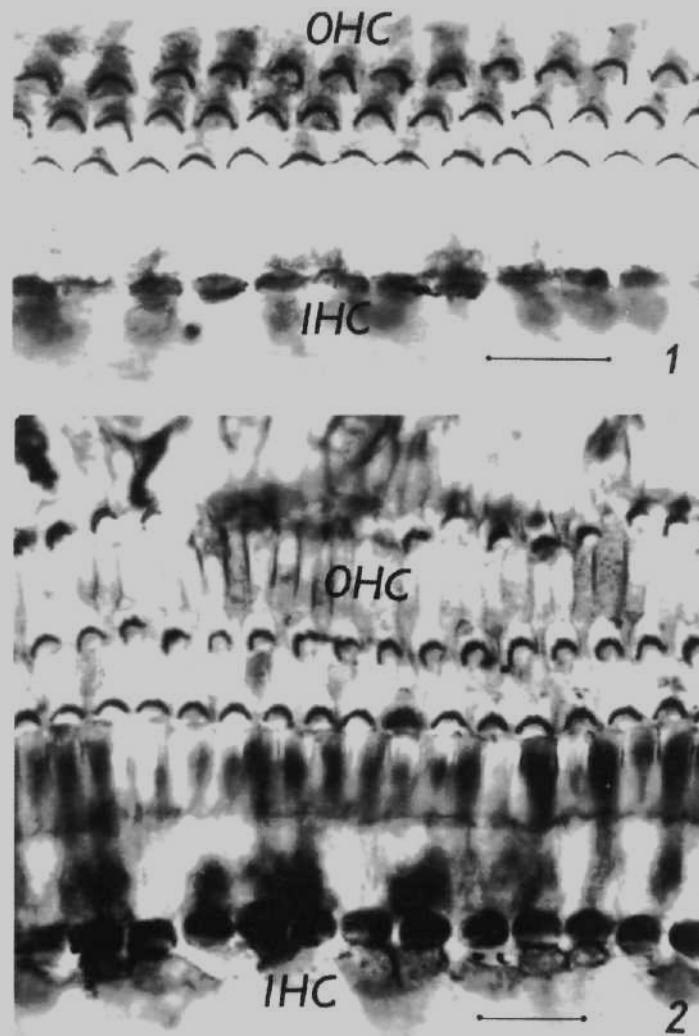


Fig. 1. Surface specimen of the organ of Corti from the basal region of the cochlea (Vervet Monkey). OHC = outer hair cells; IHC = inner hair cells. Bar = 20 micrometers.

Fig. 2. Surface specimen of the organ of Corti from the apical region of the cochlea (Vervet Monkey). OHC = outer hair cells; IHC = inner hair cells. Bar = 20 micrometers.

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(b) Lonnberg E. & Gustavson C. 1937. Contribution to the life-history of the striped wrasse. *Ark. Zool.* 29(7): 1-16.

(c) Lattin G. de 1967. *Grundriss der Zoogeographie*. Jena: Fischer Verlag, 602 pp.

(d) Makin D. 1987. The status of bats in Israel. pp. 403-408. In: Hanák V., Horáček I. & Garsler J. (eds.) *European bat research*. Praha: Charles Univ. Press, 718 pp.

(e) Schornikov E. I. 1969. A new family of Ostracoda from the supralittoral zone of Kuril islands. *Zool. Zhurnal* 48: 494-498 (in Russian, Engl. abstr.).

(f) Lekeš V. 1993. [Macrolepidoptera in middle Polabí lowland]. *Polabská Příroda* 4: 19-20 (in Czech).

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